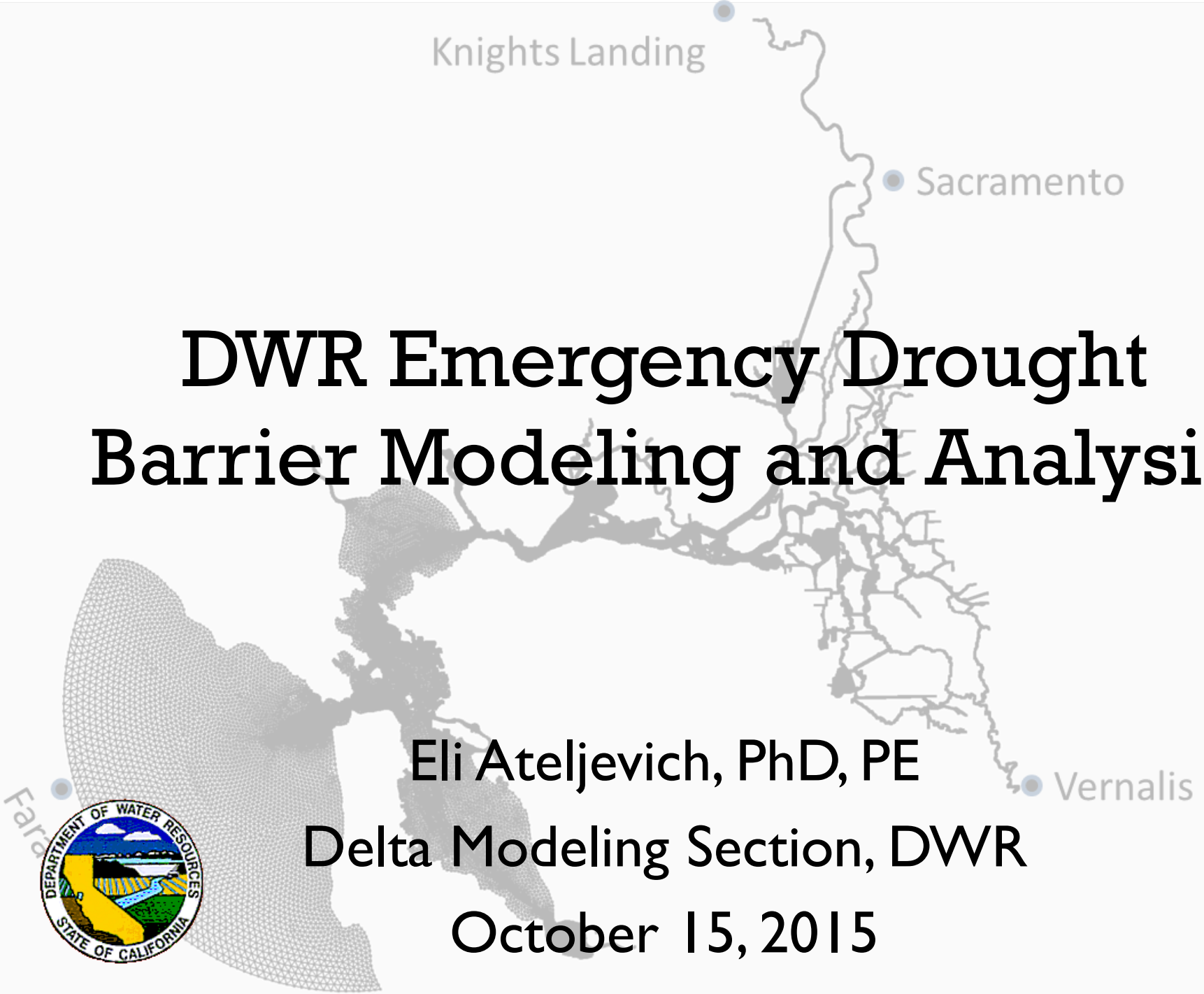


DWR Emergency Drought Barrier Modeling and Analysis

Eli Ateljevich, PhD, PE
Delta Modeling Section, DWR

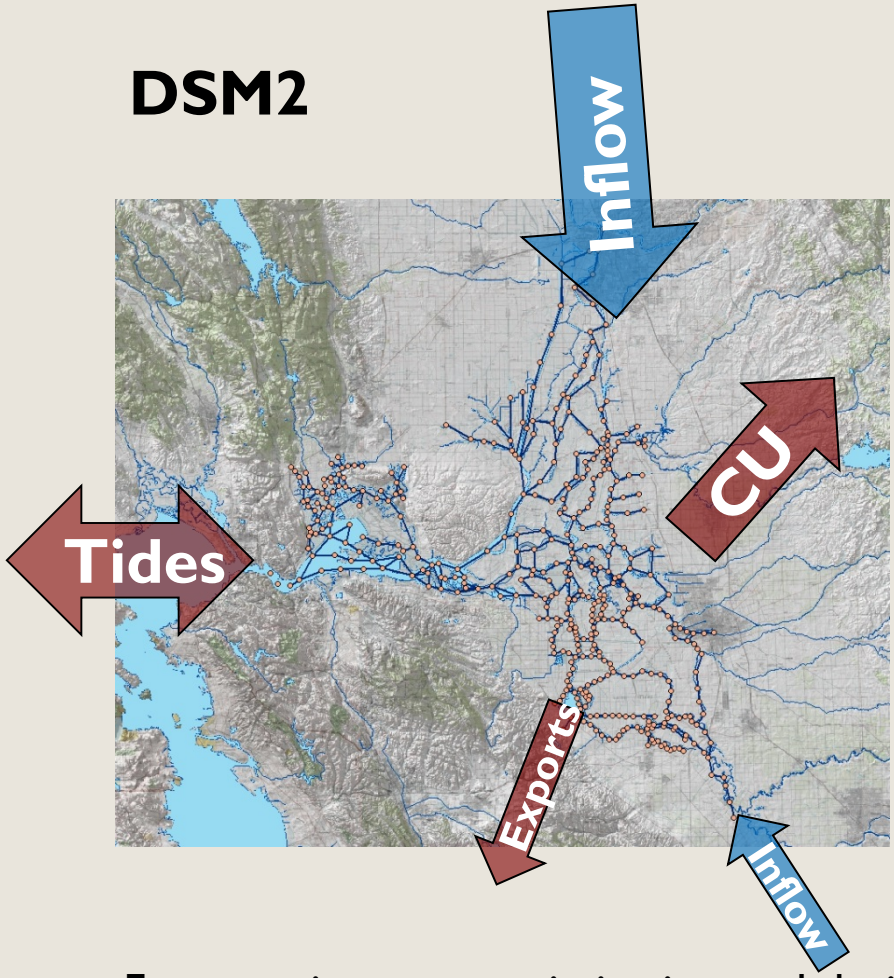
October 15, 2015

Barrier Modeling

- Screening and selection
- Water cost analyses
- How does West False River Barrier work?
- Model role in monitoring
- Operational modeling and some challenges

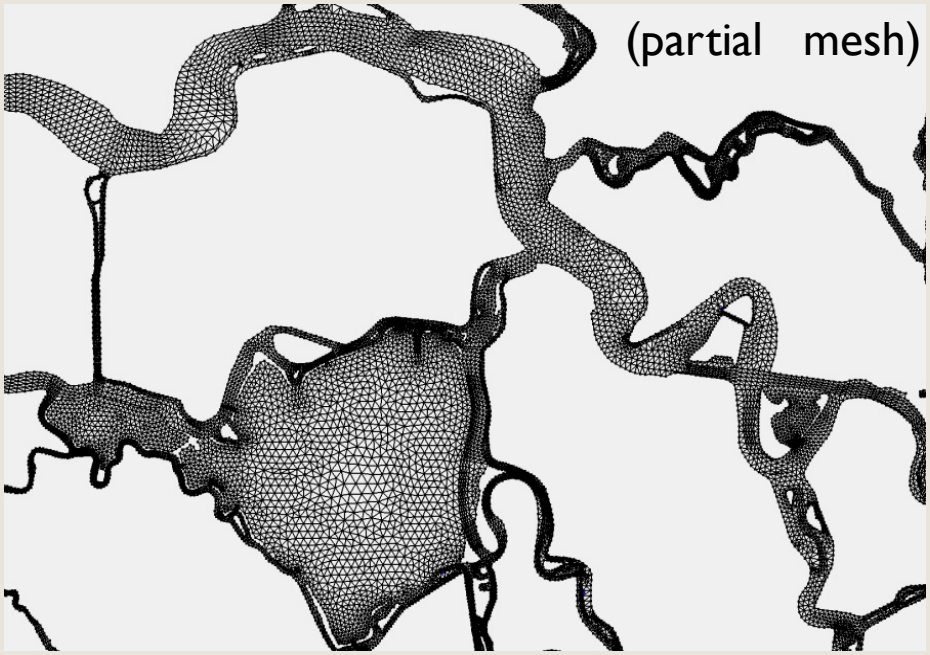
DWR Models

DSM2



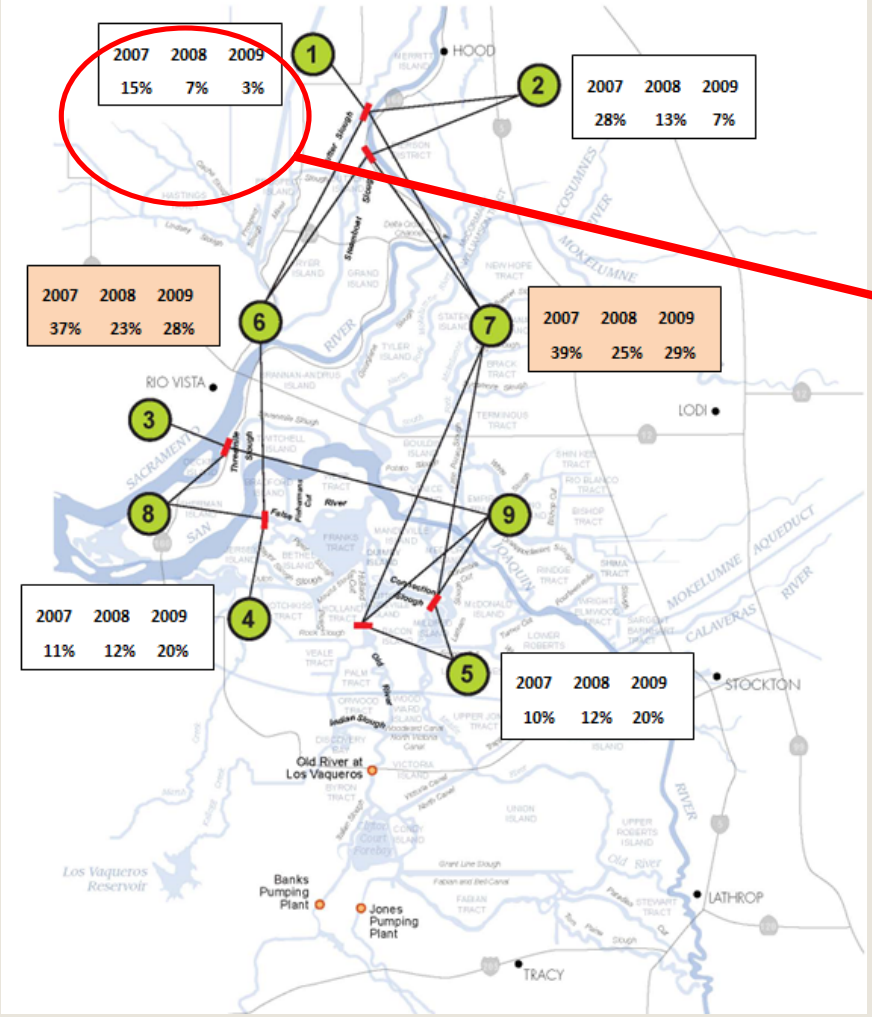
- Fast run times => optimization and design
- Rehearsed over many flow regimes

Bay-Delta SCHISM



- Accurate velocities => realistic transport
- Scalable for near field study

Screening with DSM2



Percentage Salinity Improvement at CCFB
(average July – November EC)

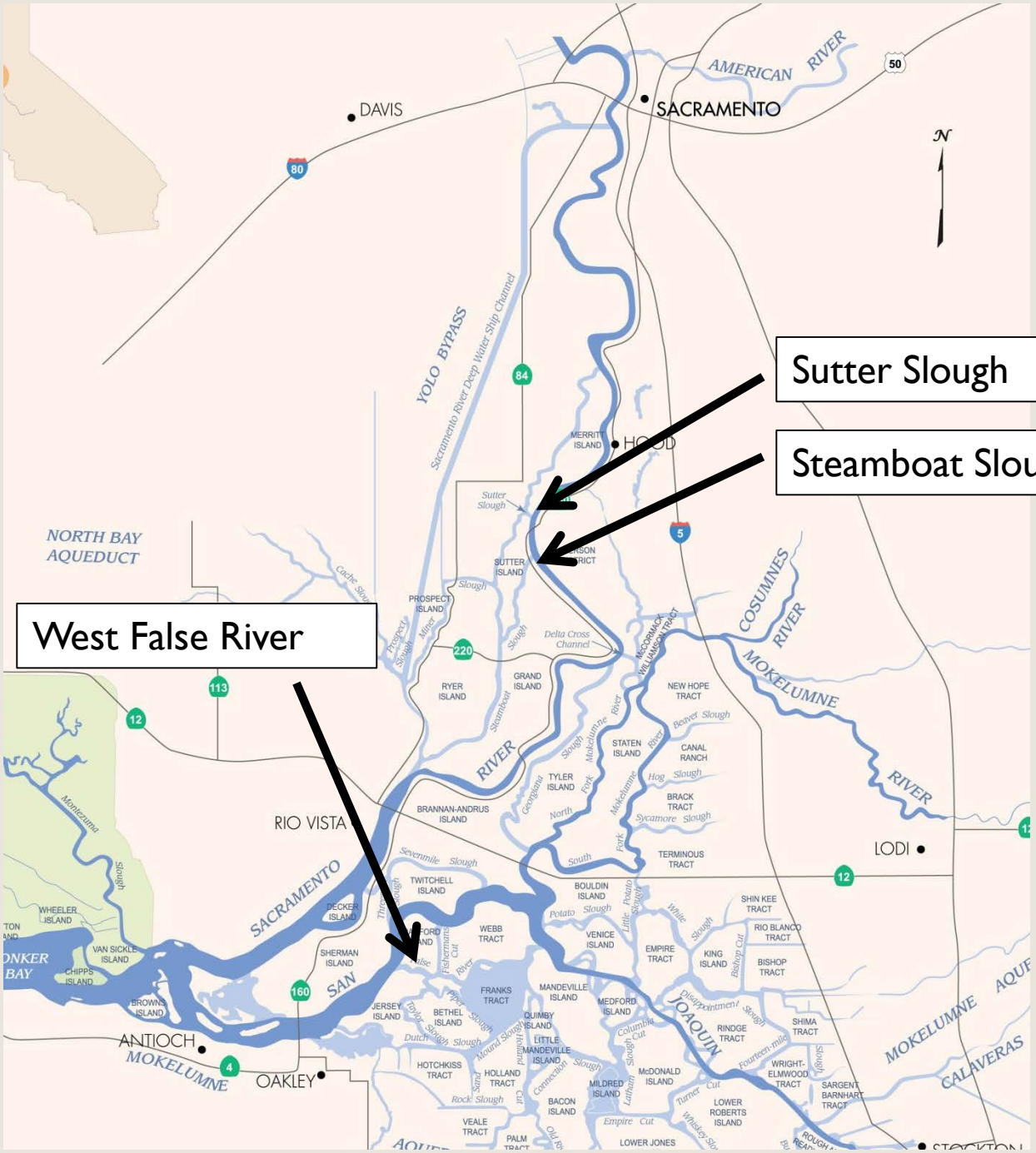
2007	2008	2009
15%	7%	3%

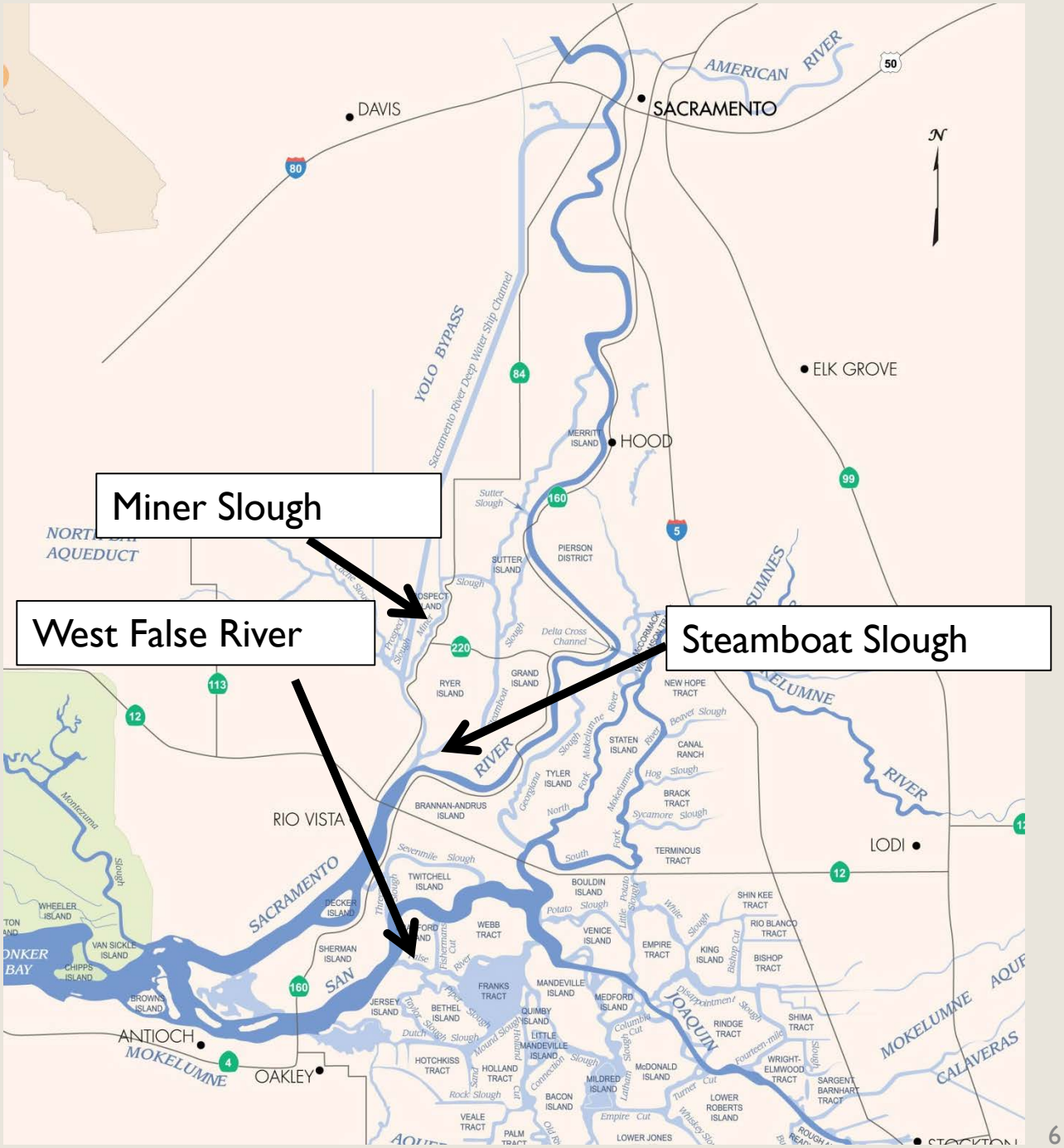
Checked against 2014 Forecast

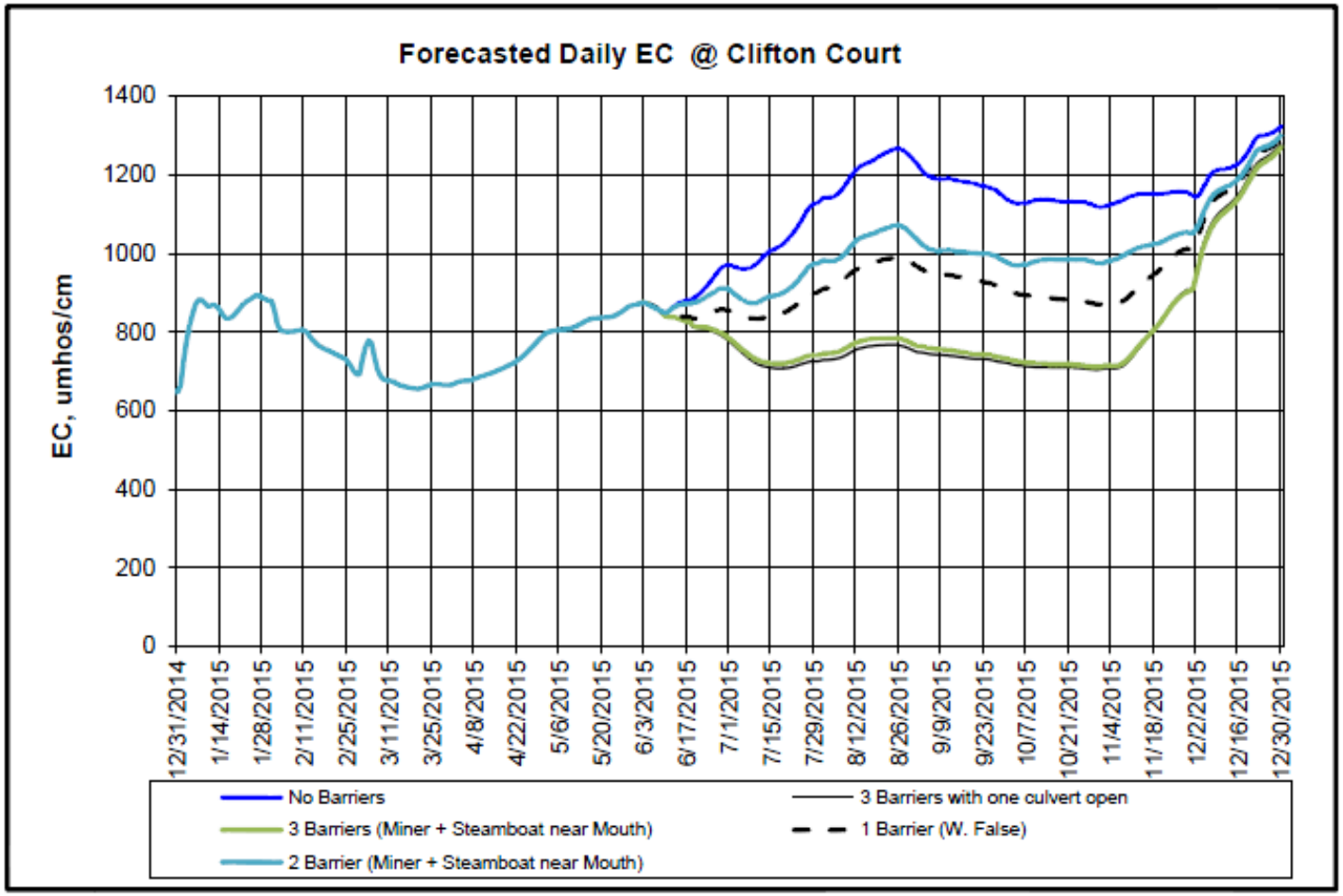
Design Inspirations:

- 1976-77 drought barriers
- 2-gate project
- Franks Tract project

2009 Emergency Barriers Draft Report
http://www.water.ca.gov/waterconditions/emergencybarriers.cfm


Sutter Slough
Steamboat Slough
West False River
DAVIS
SACRAMENTO
AMERICAN RIVER
YOLO BYPASS
Sacramento River Deep Water Ship Channel
NORTH BAY AQUEDUCT
MERRITT ISLAND
HOOD
SUTTER ISLAND
PROSPECT ISLAND
RYER ISLAND
GRAND ISLAND
Delta Cross Channel
COSUMNES RIVER
MOKELUMNE RIVER
NEW HOPE TRACT
STATEN ISLAND
CANAL RANCH
TYLER ISLAND
BRACK TRACT
BRANNAN-ANDRUS ISLAND
TERMINOUS TRACT
LODI
RIO VISTA
SACRAMENTO
SAN JOAQUIN
TWITCHELL ISLAND
BOULDIN ISLAND
DECKER ISLAND
WEBB TRACT
VENICE ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
WHEELER ISLAND
VAN SICKLE ISLAND
CHIPPS ISLAND
SHERMAN ISLAND
BROWNS ISLAND
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD ISLAND
JERSEY ISLAND
BETHEL ISLAND
QUIMBY ISLAND
RINDGE TRACT
SHIMA TRACT
LITTLE MANDEVILLE ISLAND
HOTCHKISS TRACT
HOLLAND TRACT
McDONALD ISLAND
WRIGHT-ELMWOOD TRACT
SARGENT BARNHART TRACT
MILDRED ISLAND
BACON ISLAND
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
LOWER JONES
ANTIOCH
OAKLEY
MOKELUMNE
CALAVERAS
STOCKTON
N


Miner Slough
West False River
Steamboat Slough
DAVIS
SACRAMENTO
AMERICAN RIVER
ELK GROVE
HOOD
YOLO BYPASS
Sacramento River Deep Water Ship Channel
NORTH BAY AQUEDUCT
RIO VISTA
ANTIOCH
OAKLEY
LODI
SACRAMENTO RIVER
SAN JOAQUIN
MOKELUMNE RIVER
CALAVERAS
MERRITT ISLAND
SUTTER ISLAND
PIERSON DISTRICT
GRAND ISLAND
RYER ISLAND
NEW HOPE TRACT
STATEN ISLAND
CANAL RANCH
TYLER ISLAND
BRACK TRACT
BRANNAN-ANDRUS ISLAND
TERMINOUS TRACT
TWITCHELL ISLAND
BOULDIN ISLAND
SHIN KEE TRACT
RIO BLANCO TRACT
WEBB TRACT
VENICE ISLAND
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
DECKER ISLAND
SHERMAN ISLAND
WHEELER ISLAND
VAN SICKLE ISLAND
CHIPPS ISLAND
BROWNS ISLAND
JERSEY ISLAND
BETHEL ISLAND
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD ISLAND
QUIMBY ISLAND
LITTLE MANDEVILLE ISLAND
RINDGE TRACT
SHIMA TRACT
HOTCHKISS TRACT
HOLLAND TRACT
MILDRED ISLAND
McDONALD ISLAND
WRIGHT-ELMWOOD TRACT
SARGENT BARNHART TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
VEALE TRACT
PALM TRACT
LOWER JONES
Montezuma Slough
Sutter Slough
Delta Cross Channel
Beaver Slough
Hog Slough
Sycamore Slough
Potato Slough
Disappointment Slough
Fourteen-mile Slough
Mound Slough
Dutch Slough
Rock Slough
Empire Cut
Turner Cut
Whiskey Slo
Fisherman's Cut
Bishop Cut
Columbia Cut
Latham Slough
Connection Slough
Old River
Seventmile Slough
Georgiana Slough
North Fork Mokelumne River
South Fork Mokelumne River
Little Potato Slough
White Slough
Mokelumne Aque
50
80
84
160
5
99
220
113
12
4
13



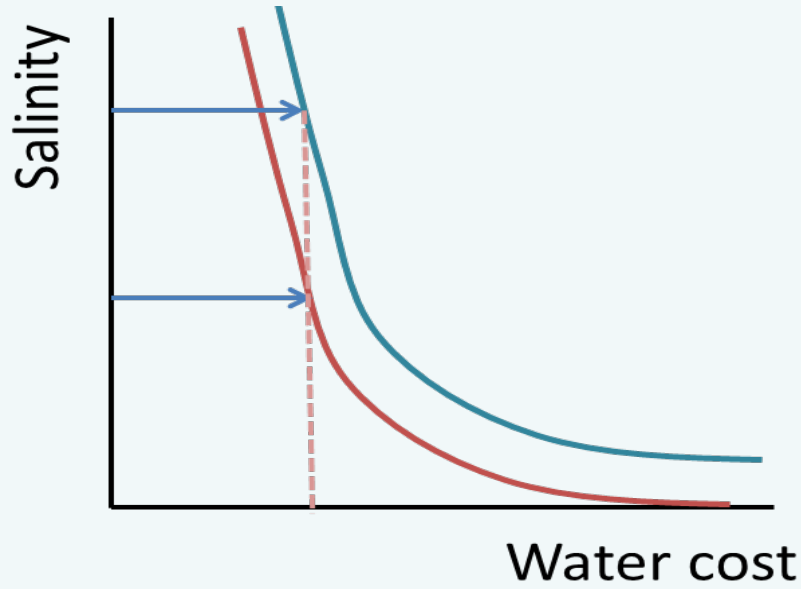
DSM2 Water Quality Using Hydrology for IS-MND

(Initial Study – Mitigated Negative Declaration)

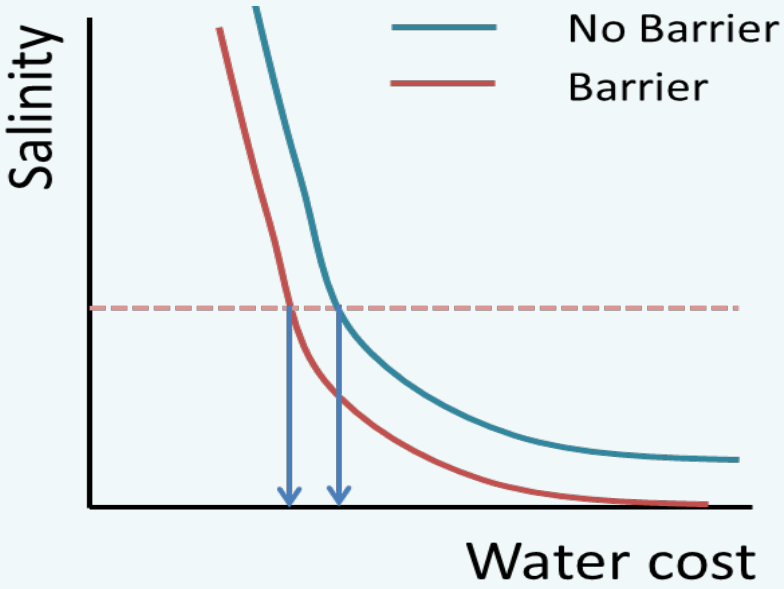
Barrier Topics

- Screening and selection ✓
- Water cost analyses ➡
- How does West False River Barrier work?
- Model role in monitoring
- Models and project operation
- Operational modeling and some challenges

Water Cost: Quality ≠ Quantity



Large salinity change for fixed flow pattern



Small water cost savings for fixed salinity constraint

Water Cost Analysis

- Minimize sum of outflow that …
- Meets D-1641 EC (or anything you want)***
- Constrained Optimization By Linear Approximation (COBYLA)
- Regularization to get rid of whacky results
- (Most) solutions are "in the calibration zone"

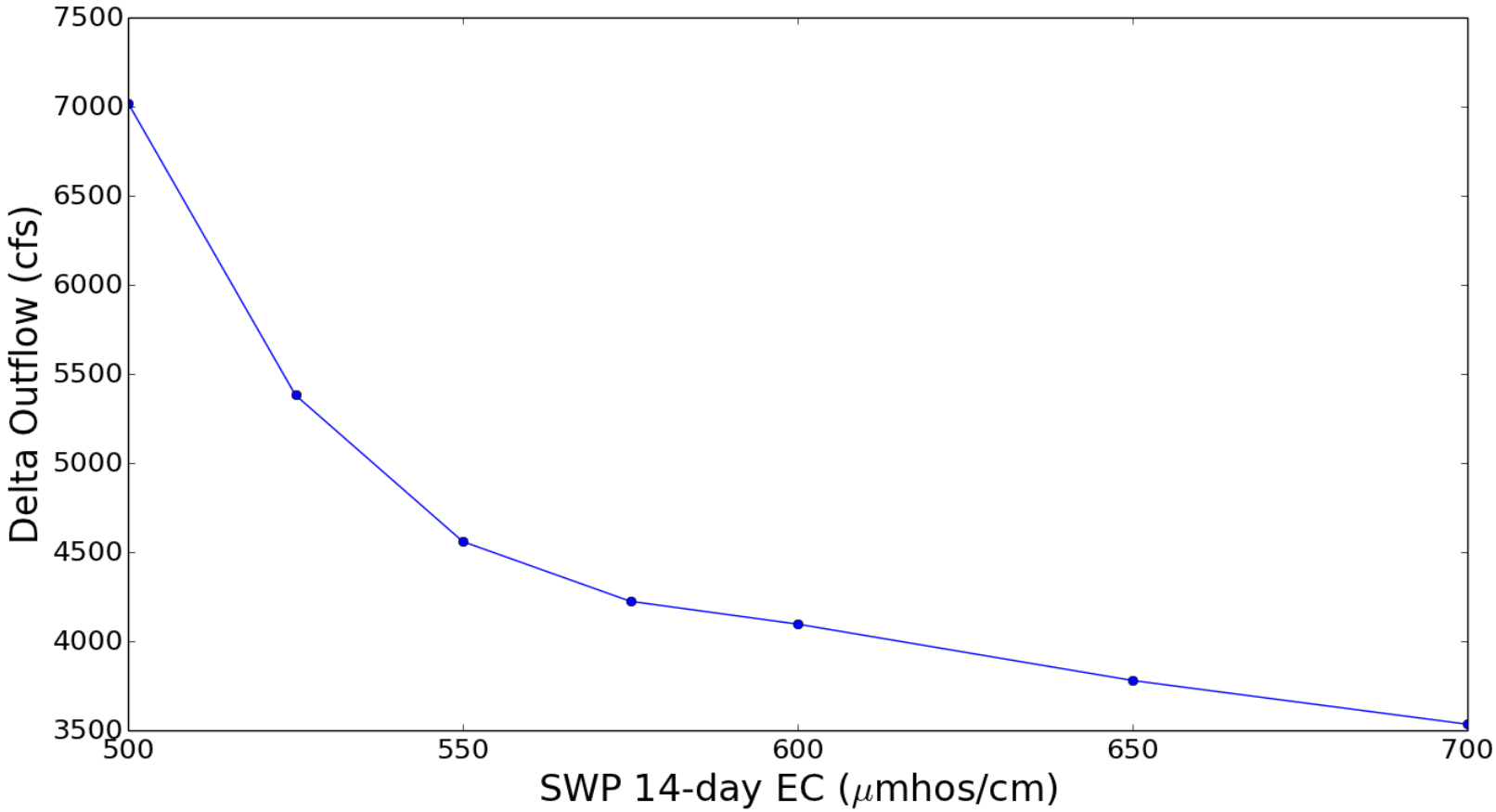
*** D-1641 was modified in 2015: Emmaton ag standard moved to Threemile and Outflow requirements in spring/early summer relaxed.

Main Water Cost Result

Objective	Emergency Barriers	Without Barriers
Emmaton	3893 cfs	3657 cfs
Three Mile	3050 cfs	3045 cfs
Relaxed	2769 cfs	3045 cfs

Water cost is bound by TUCP and Sacramento ag standard, mostly a tie

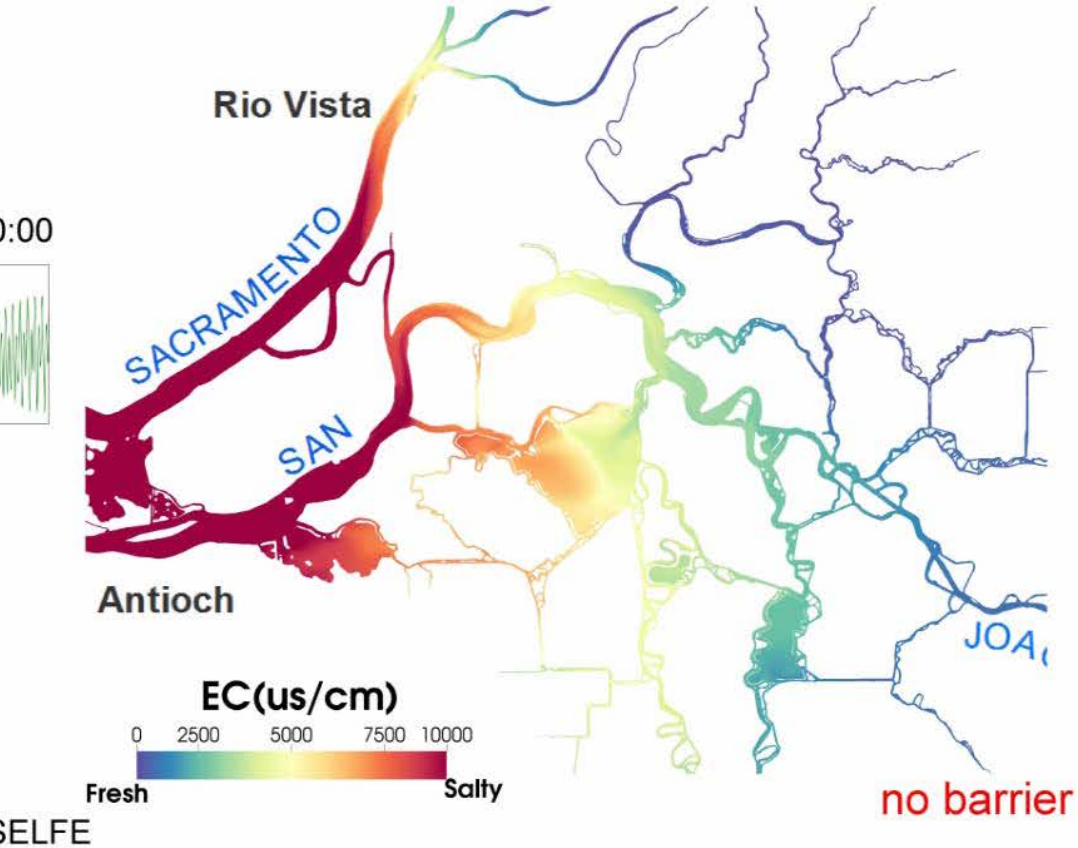
Bromide and Clifton Court



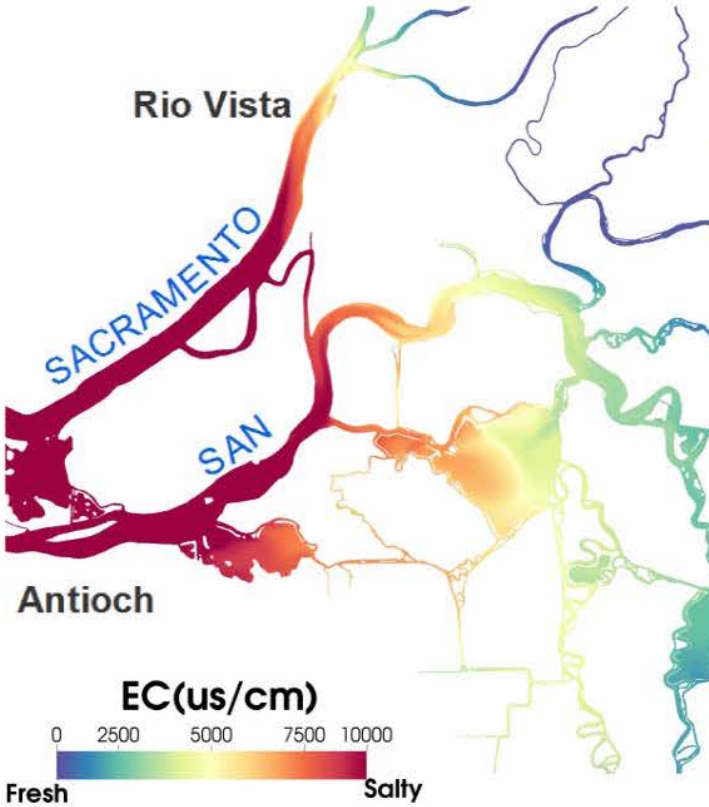
Costs are dependent on initial state

Barrier Topics

- Screening and selection ✓
- Water cost analyses ✓
- How does West False River Barrier work? ➡
- Model role in monitoring
- Models and project operation
- Operational modeling and some challenges

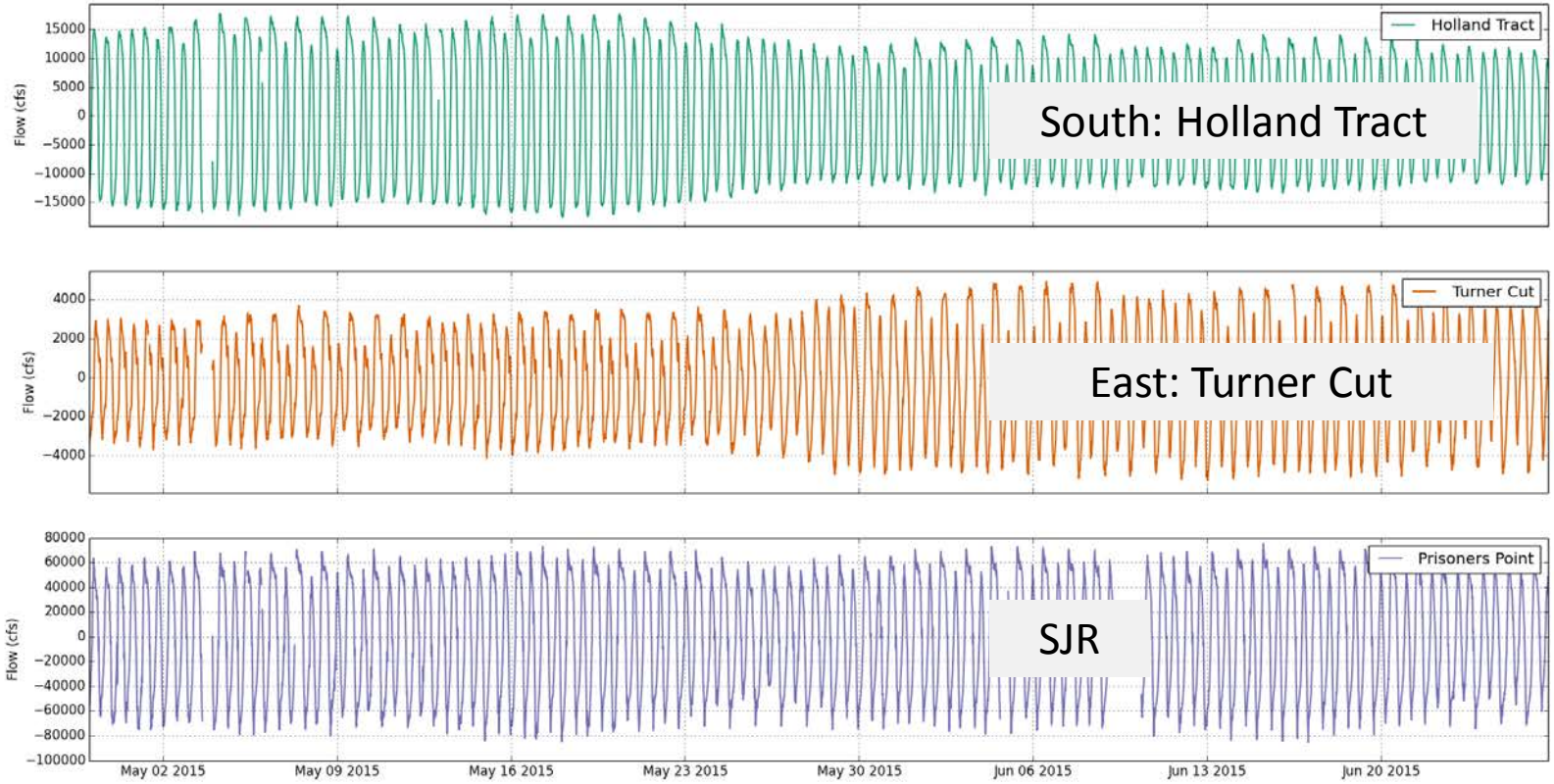


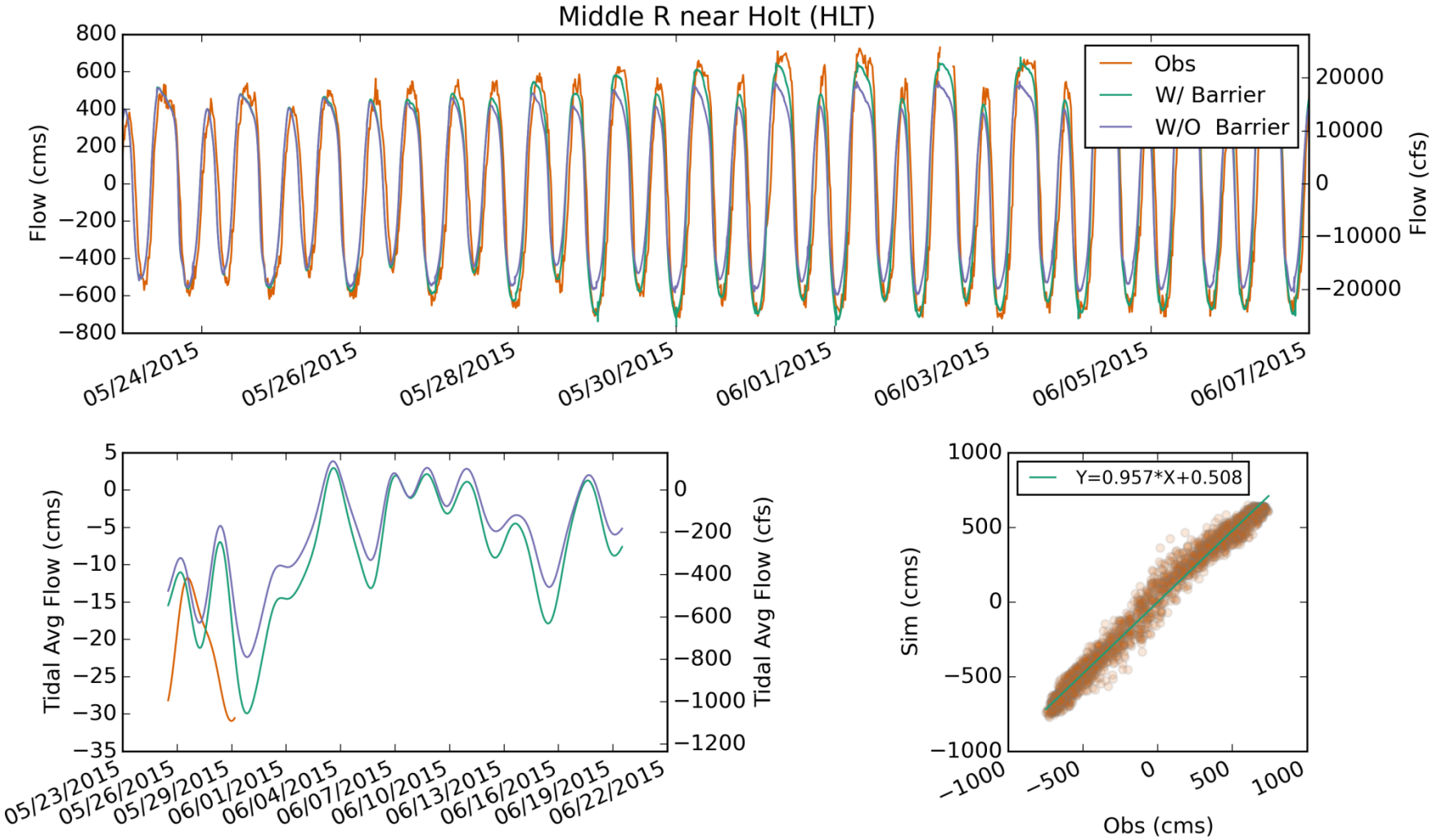
no barrier



Delta EC (Low NDO)

Flow Change Near Franks Tract

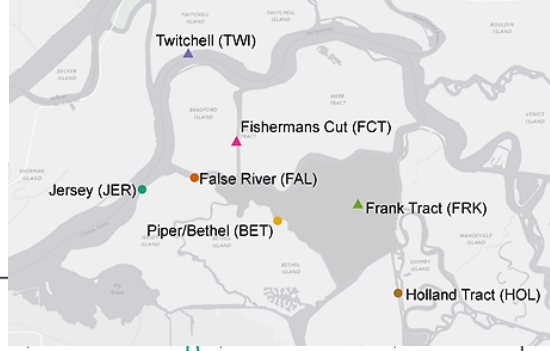


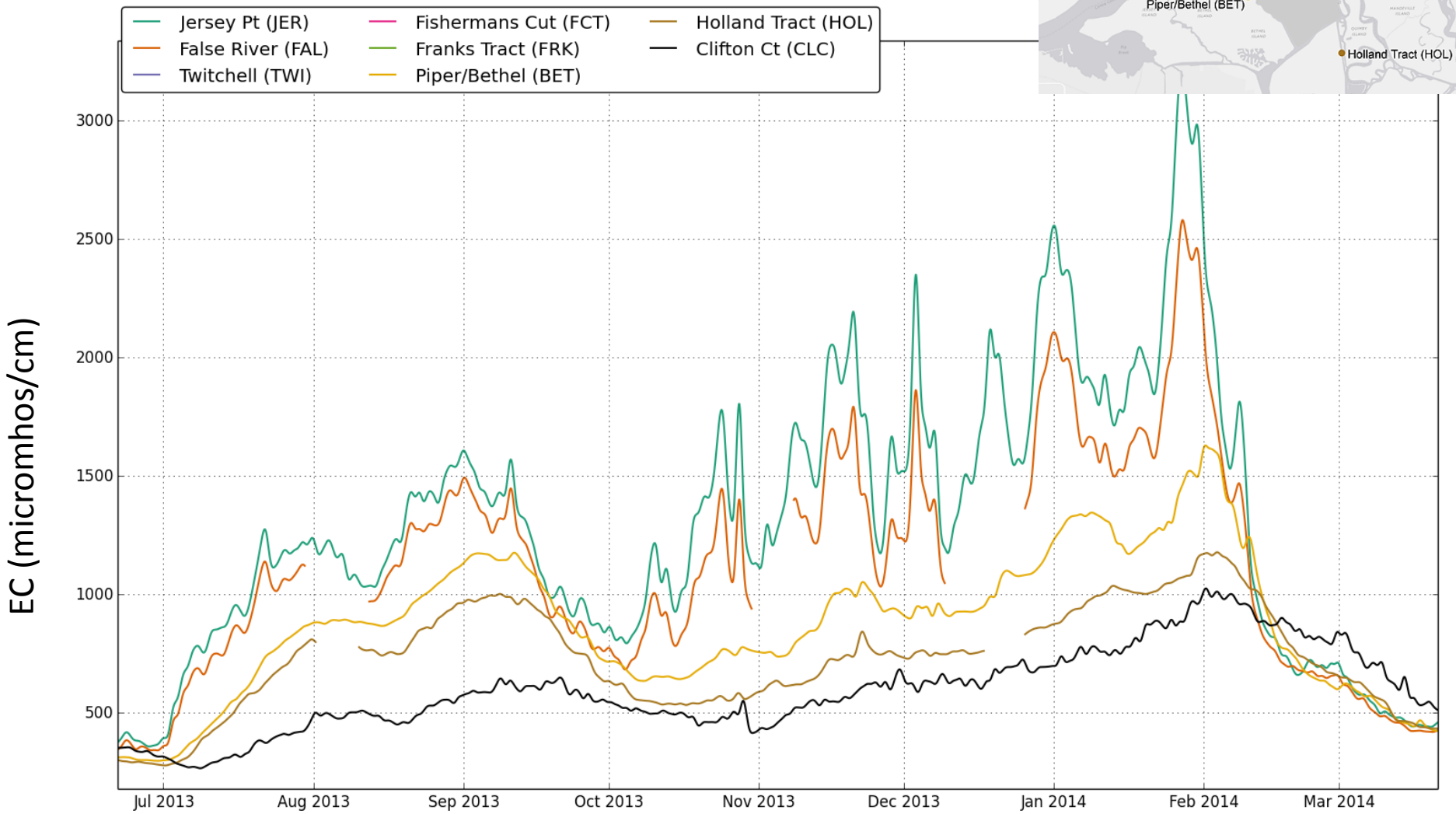


W/ Barrier: RMSE=160.992 cms Lag=-35 min $Bias_{\phi}$=-0.318 NSE_{ϕ}=0.981 R_{ϕ}=0.991

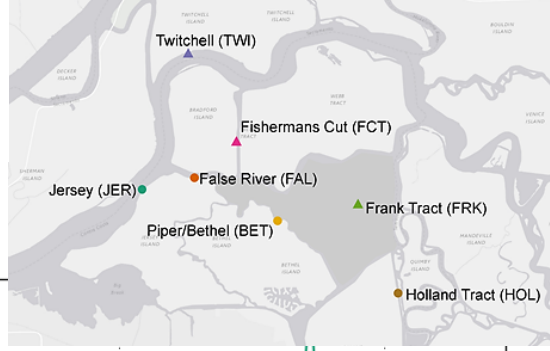
W/O Barrier: RMSE=202.692 cms Lag=-45 min $Bias_{\phi}$=20.850 NSE_{ϕ}=0.947 R_{ϕ}=0.989

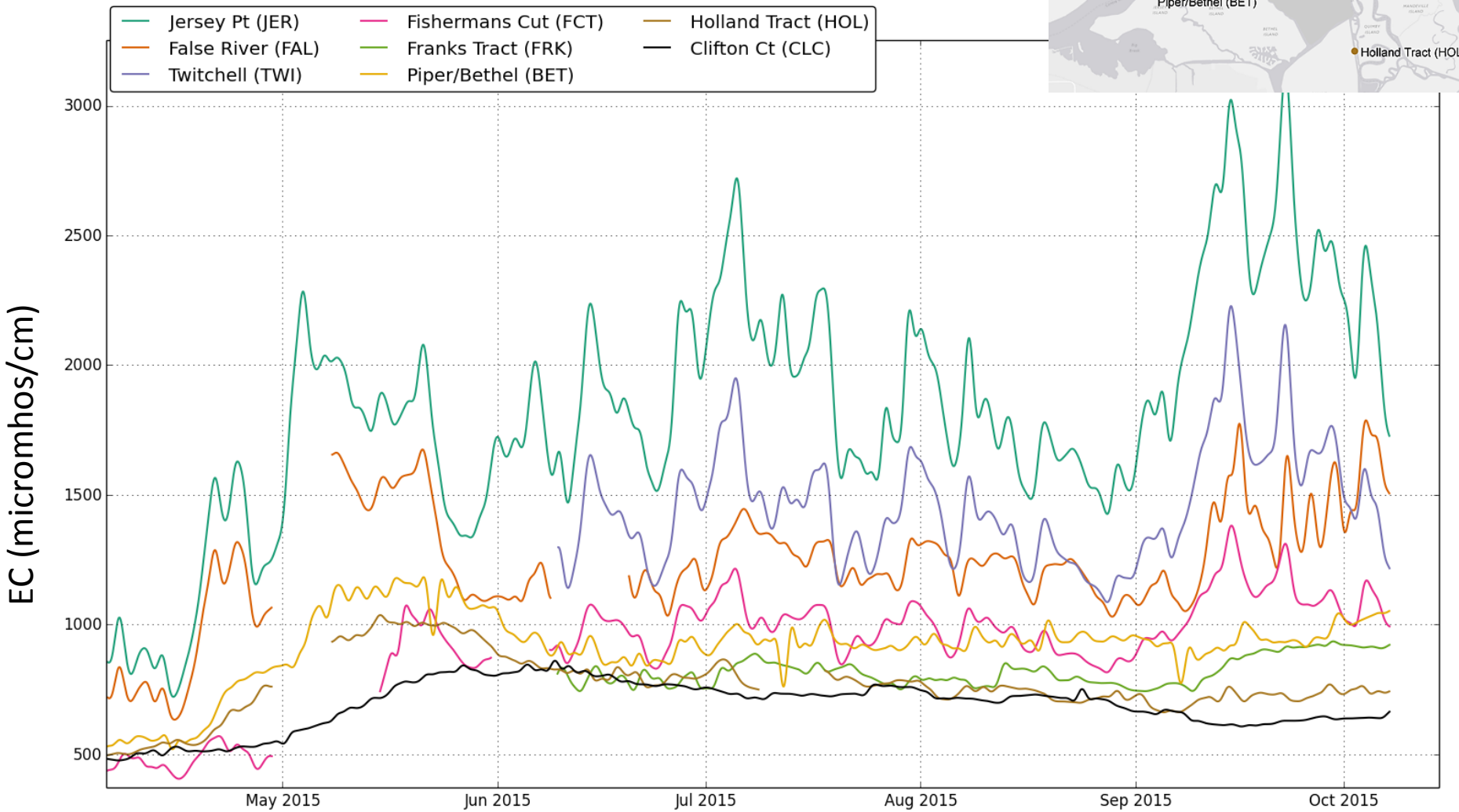
2013-14

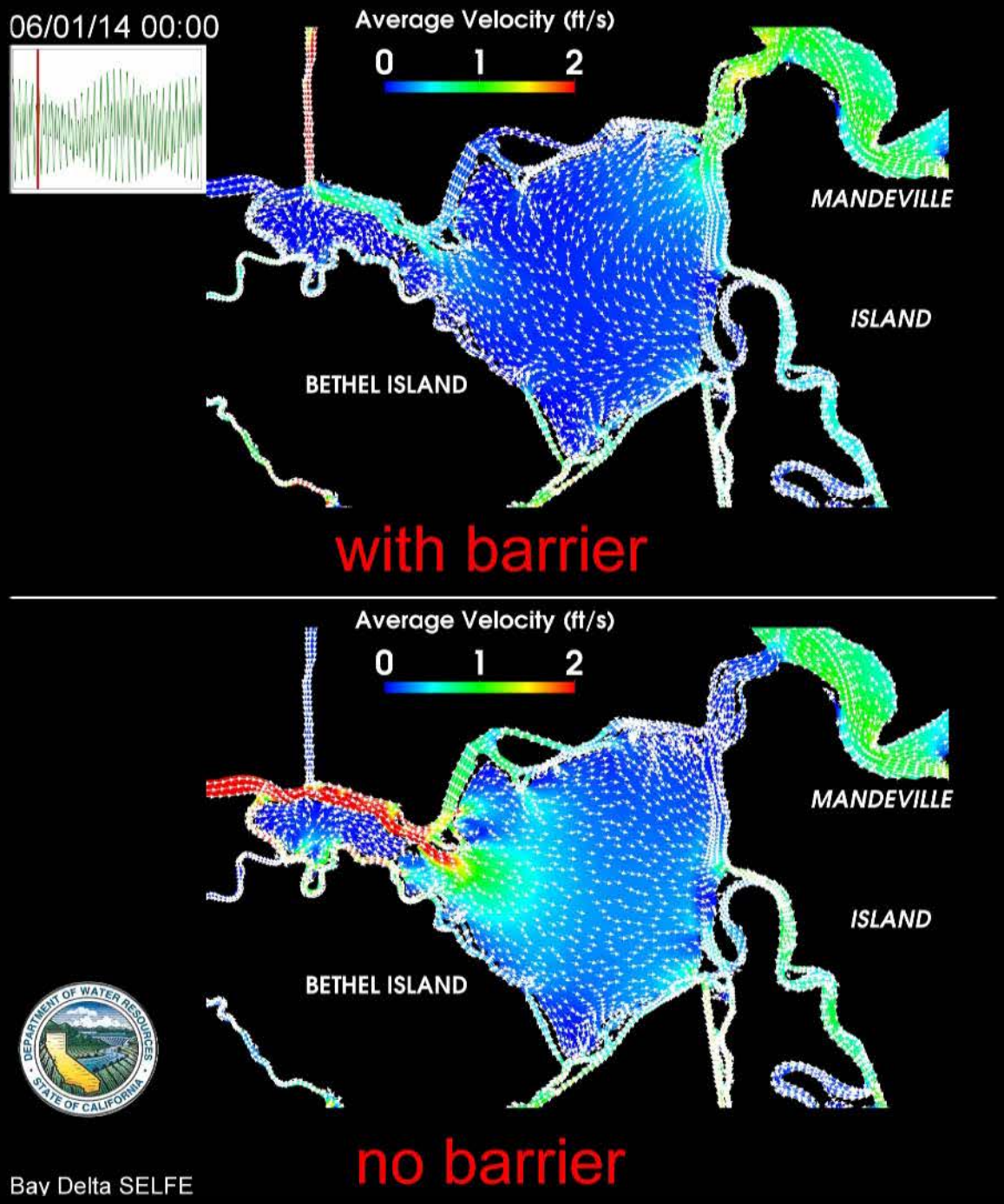

Twitchell (TWI)
Fishermans Cut (FCT)
False River (FAL)
Jersey (JER)
Frank Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)

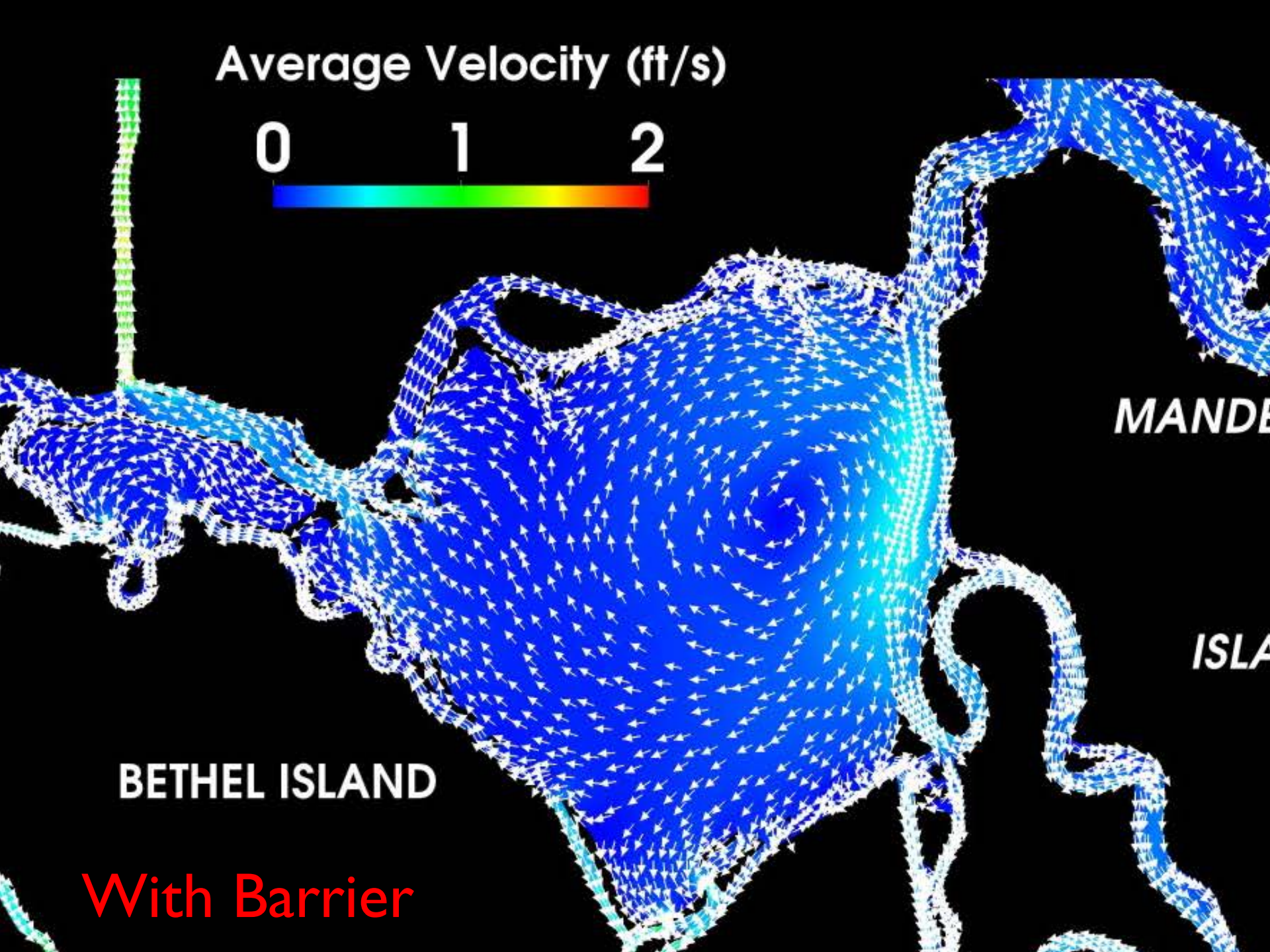

Jersey Pt (JER)
False River (FAL)
Twitchell (TWI)
Fishermans Cut (FCT)
Franks Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)
Clifton Ct (CLC)
EC (micromhos/cm)
3000
2500
2000
1500
1000
500
Jul 2013
Aug 2013
Sep 2013
Oct 2013
Nov 2013
Dec 2013
Jan 2014
Feb 2014
Mar 2014

2015


Twitchell (TWI)
Fishermans Cut (FCT)
False River (FAL)
Jersey (JER)
Frank Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)


Jersey Pt (JER)
False River (FAL)
Twitchell (TWI)
Fishermans Cut (FCT)
Franks Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)
Clifton Ct (CLC)
EC (micromhos/cm)
3000
2500
2000
1500
1000
500
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015


06/01/14 00:00
Average Velocity (ft/s)
0 1 2
MANDEVILLE
ISLAND
BETHEL ISLAND
with barrier
Average Velocity (ft/s)
0 1 2
MANDEVILLE
ISLAND
BETHEL ISLAND
DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA
no barrier
Bay Delta SELFE

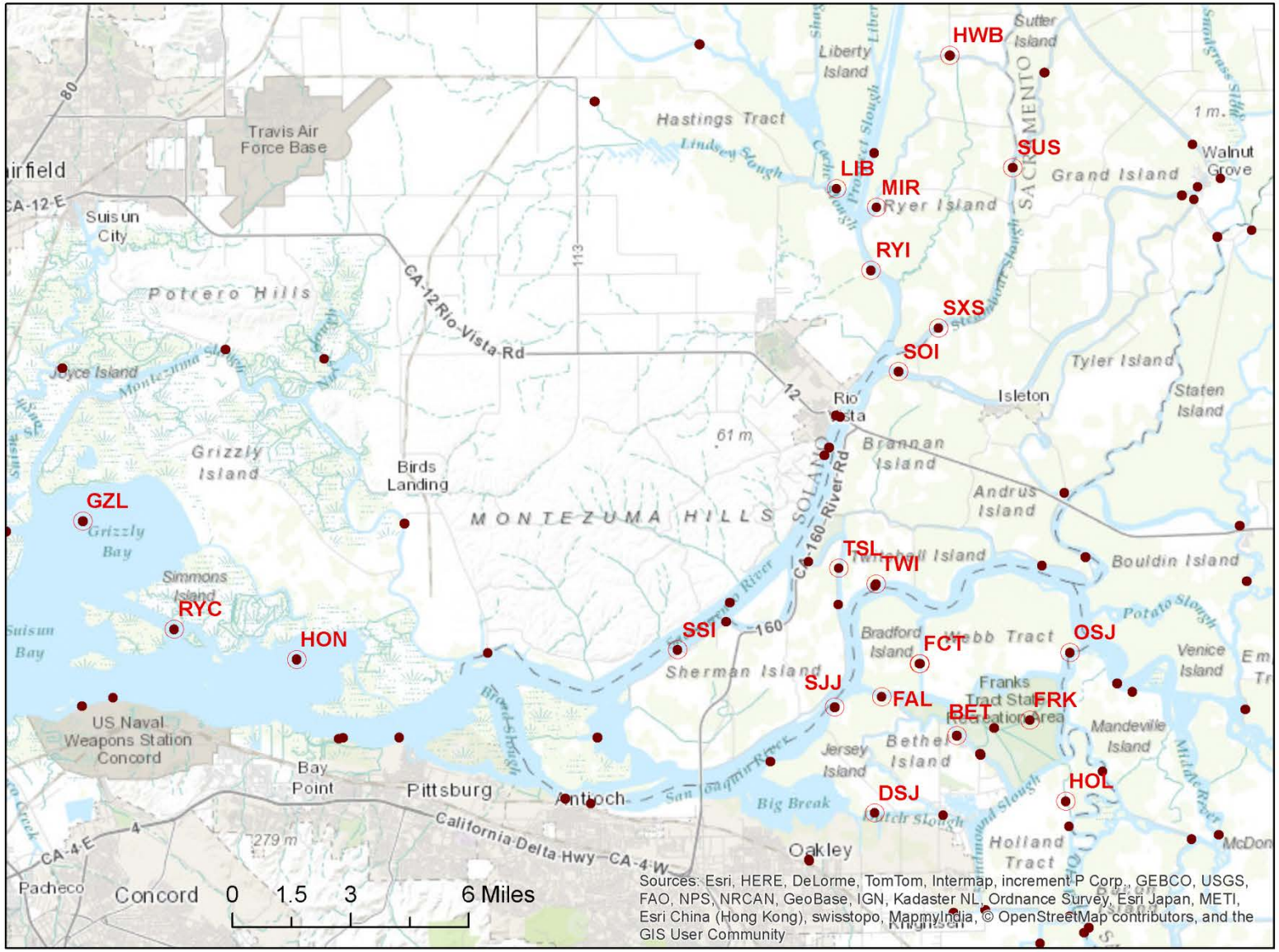

Average Velocity (ft/s)
0
1
2
MANDE
ISLA
BETHEL ISLAND
With Barrier

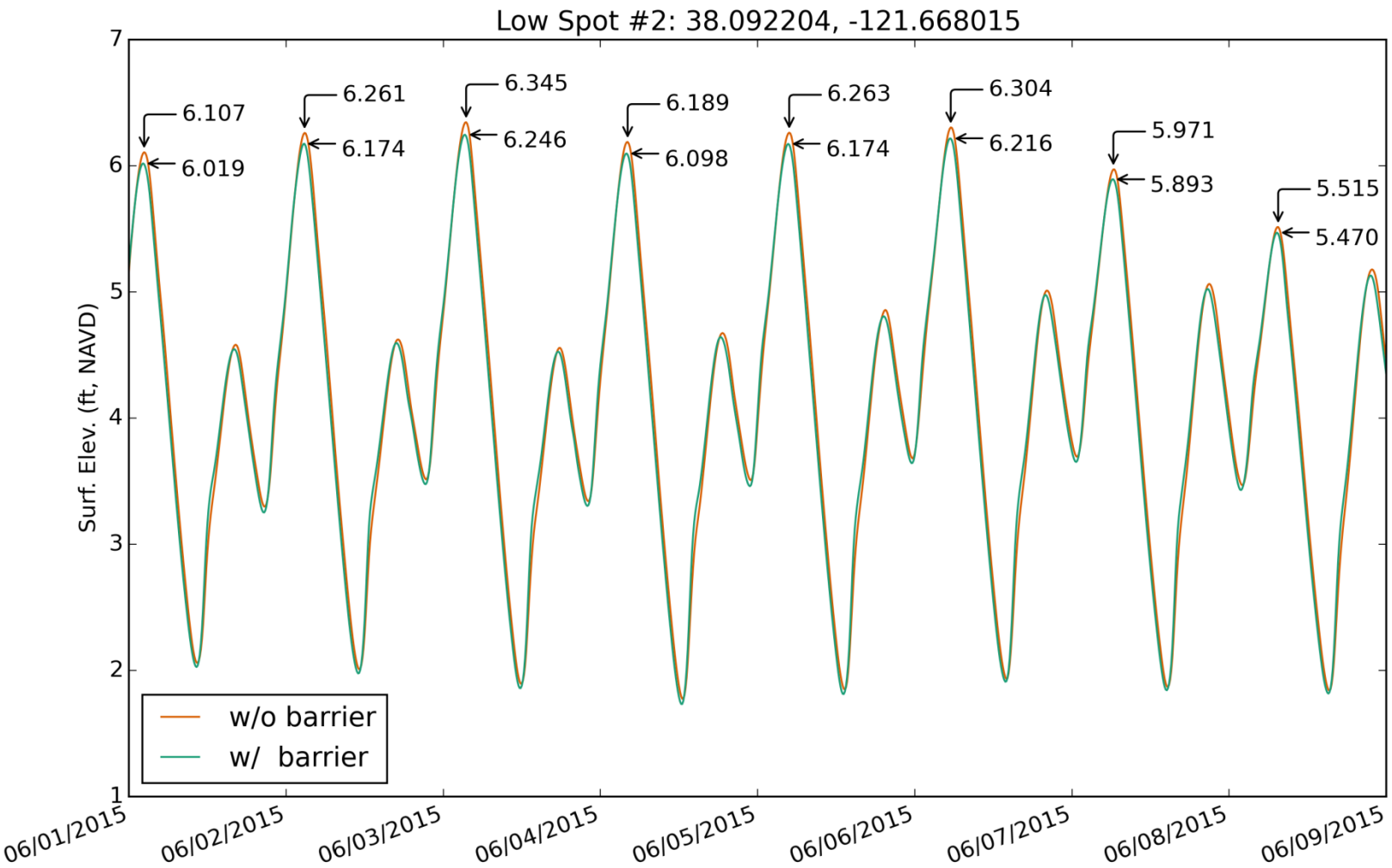
Barrier Topics

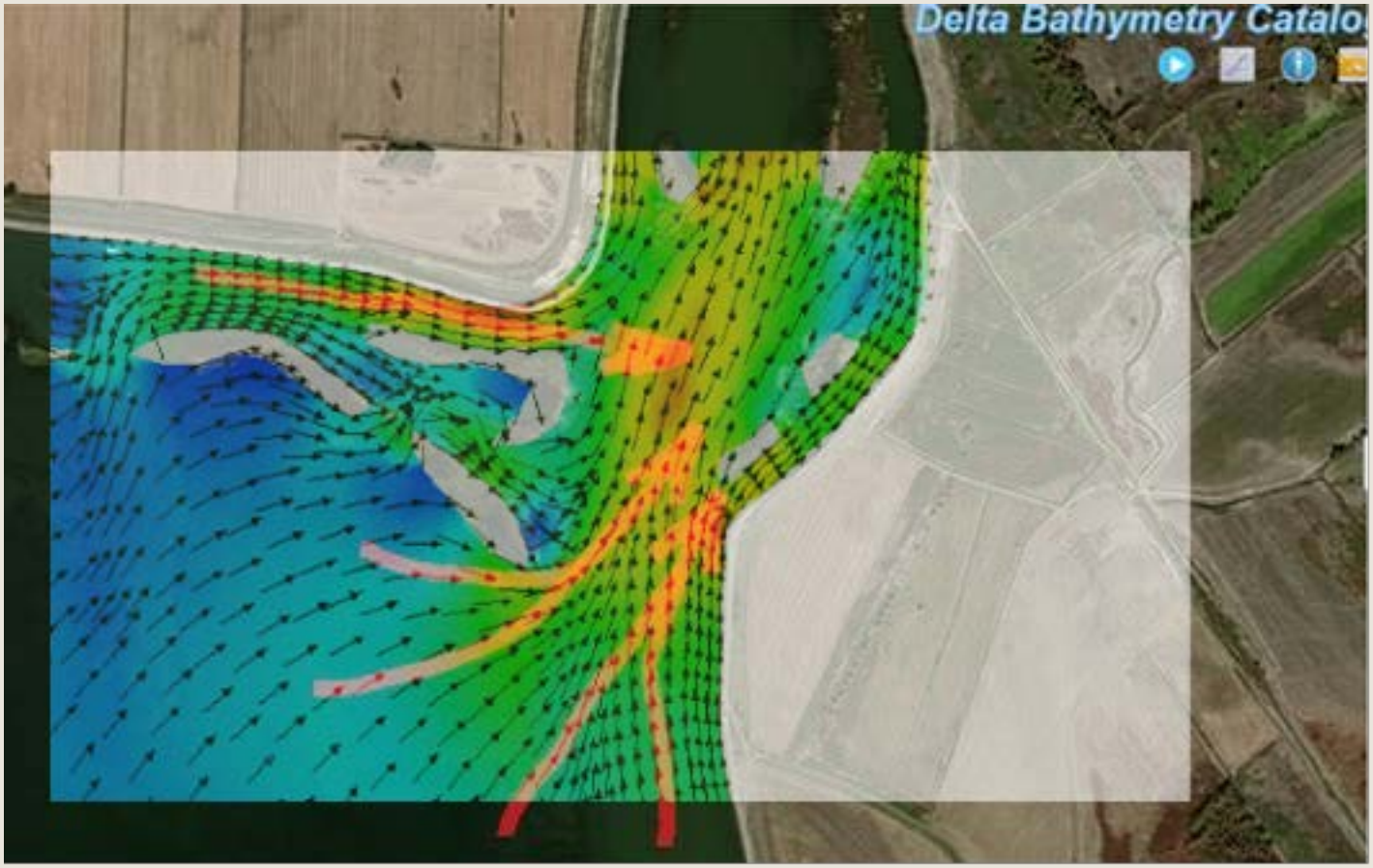
- Screening and selection ✓
- Water cost analyses ✓
- How does West False River Barrier work? ✓
- Model role in monitoring ➡
- Operational modeling and some challenges

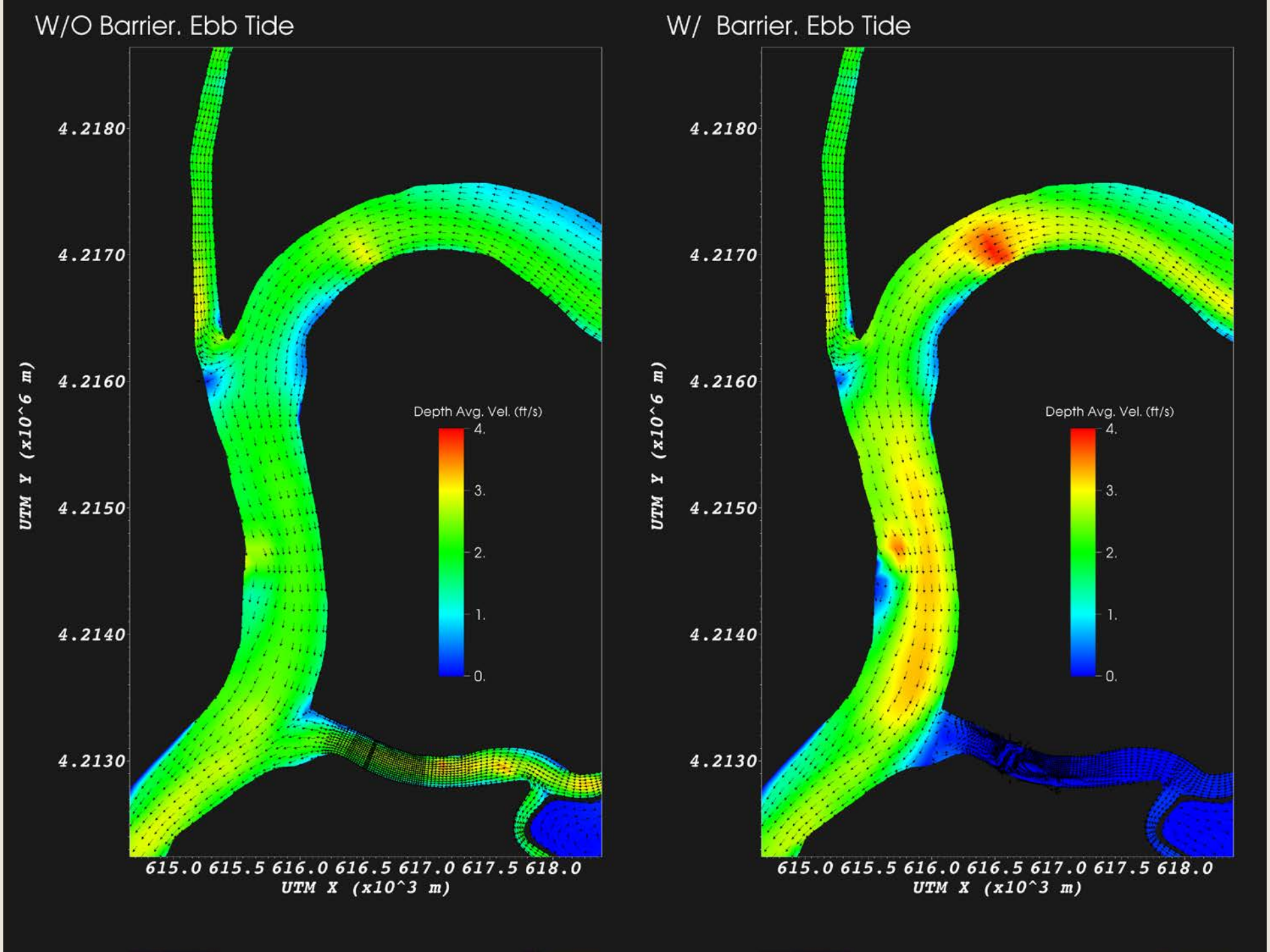
Models and Monitoring

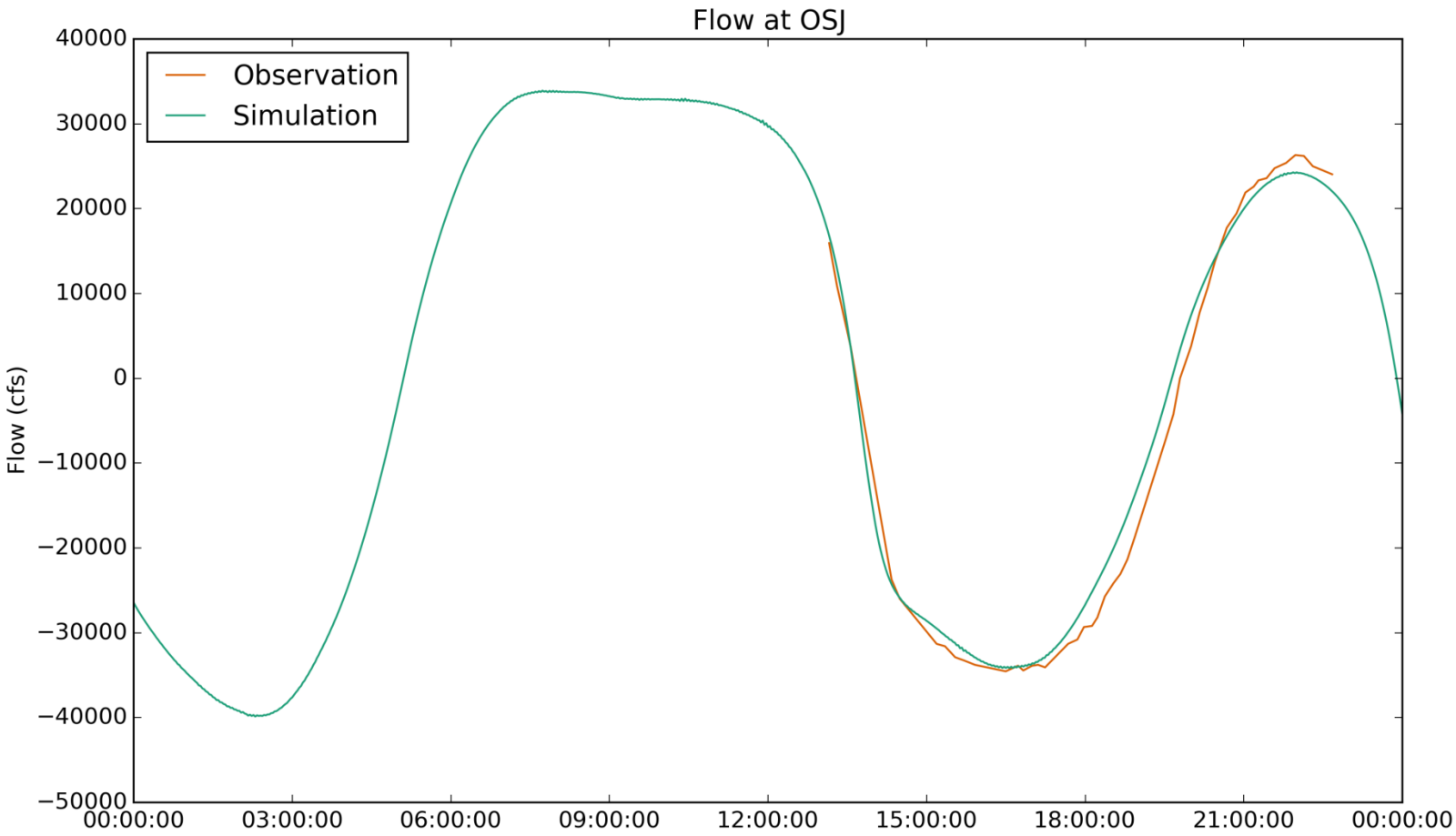
- New stations
- Sanity check of flow stations
- Virtual triage of probable hot spots.
- Velocity modeling accuracy quite good
  - Bathymetry dependent
  - Resolution dependent
- Bathymetry
  - Easier to cover than velocity, harder than model
  - Bathymetry is the bottom line answer
  - Turbulent effects: no Reynolds averaging here!!


HWB
SUS
LIB
MIR
RYI
SXS
SOI
GZL
RYC
HON
SSI
TSL
TWI
OSJ
FCT
SJJ
FAL
BET
FRK
DSJ
HOL
Travis Air Force Base
Suisun City
Potrero Hills
Hastings Tract
Liberty Island
Sutter Island
Grand Island
Walnut Grove
Ryer Island
Tyler Island
Staten Island
Isleton
Rio Vista
Brannan Island
Andrus Island
Bouldin Island
Grizzly Island
Birds Landing
MONTEZUMA HILLS
Grizzly Bay
Simmons Island
Suisun Bay
Sherman Island
Bradford Island
Webb Tract
Venice Island
Franks Tract State Recreation Area
Mandeville Island
Bethel Island
Jersey Island
Big Break
Holland Tract
US Naval Weapons Station Concord
Bay Point
Pittsburg
Antioch
Oakley
Pacheco
Concord
CA-12 Rio Vista Rd
CA-160 River Rd
California Delta Hwy CA-4 W
0 1.5 3 6 Miles
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Low Spot #2: 38.092204, -121.668015
Surf. Elev. (ft, NAVD)
7
6
5
4
3
2
1
6.107
6.019
6.261
6.174
6.345
6.246
6.189
6.098
6.263
6.174
6.304
6.216
5.971
5.893
5.515
5.470
w/o barrier
w/ barrier
06/01/2015
06/02/2015
06/03/2015
06/04/2015
06/05/2015
06/06/2015
06/07/2015
06/08/2015
06/09/2015


Delta Bathymetry Catalo


W/O Barrier. Ebb Tide
W/ Barrier. Ebb Tide
Depth Avg. Vel. (ft/s)
4.
3.
2.
1.
0.
4.2180
4.2170
4.2160
4.2150
4.2140
4.2130
UTM Y (x10^6 m)
615.0 615.5 616.0 616.5 617.0 617.5 618.0
UTM X (x10^3 m)


Flow at OSJ
Observation
Simulation
Flow (cfs)
40000
30000
20000
10000
0
−10000
−20000
−30000
−40000
−50000
00:00:00
03:00:00
06:00:00
09:00:00
12:00:00
15:00:00
18:00:00
21:00:00
00:00:00

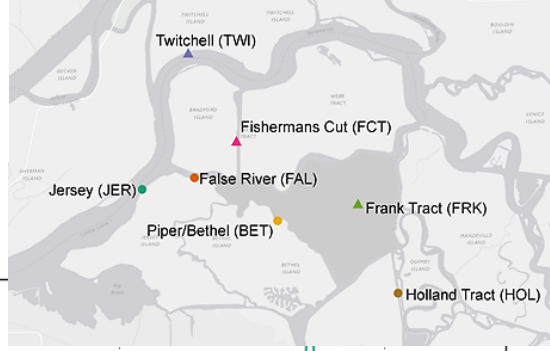
Barrier Topics

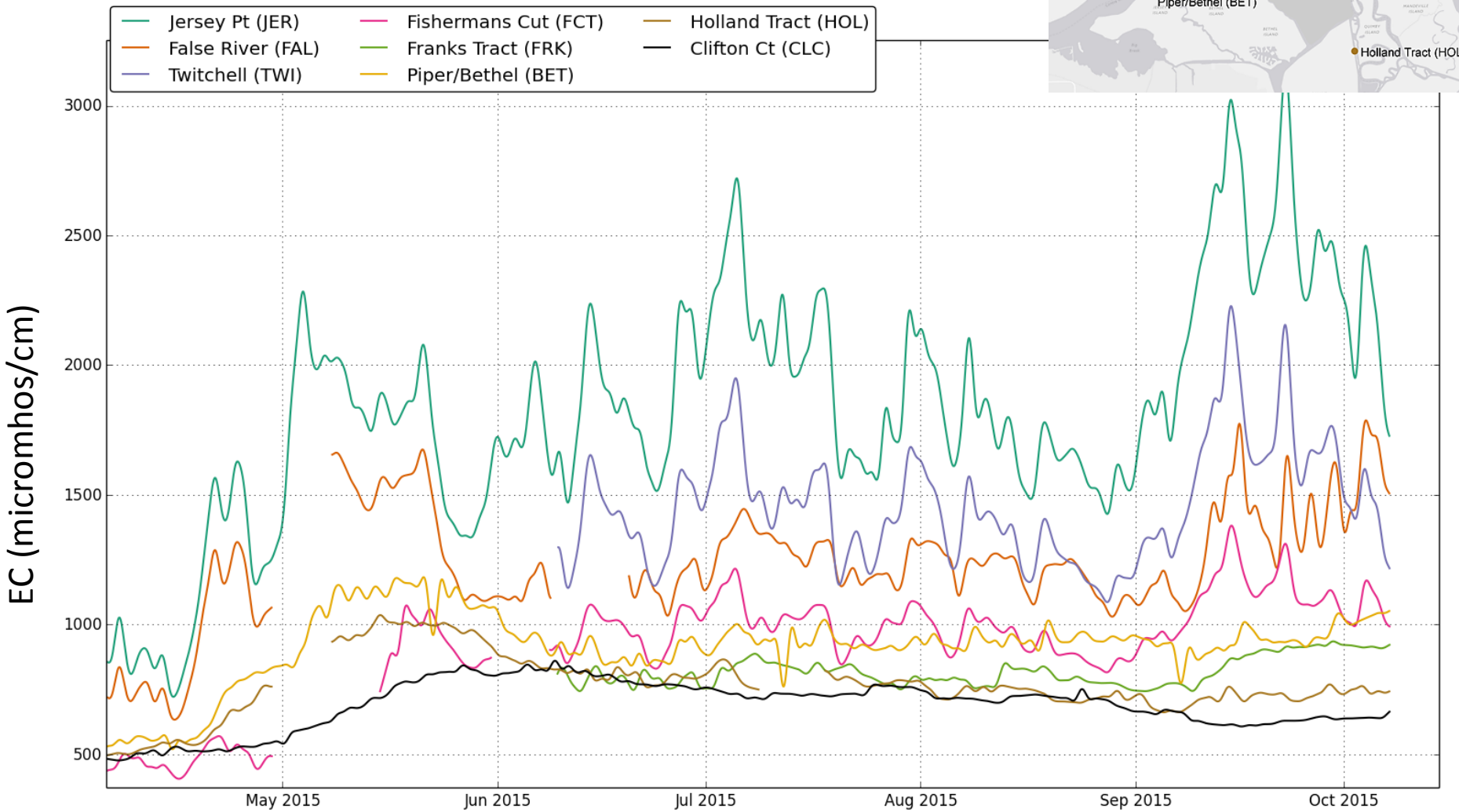
- Screening and selection ✓
- Water cost analyses ✓
- How does the West False River Barrier work? ✓
- Model role in monitoring✓
- Operational modeling and some challenges ➡

Operational Modeling

- Many decisions are (days) upstream
- Quick control: pumping
- Consumptive use not known
  - Often not much different from yesterday
- Punctuated by events on short notice
  - Particularly low pressure events offshore

2015


Twitchell (TWI)
Fishermans Cut (FCT)
False River (FAL)
Jersey (JER)
Frank Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)


Jersey Pt (JER)
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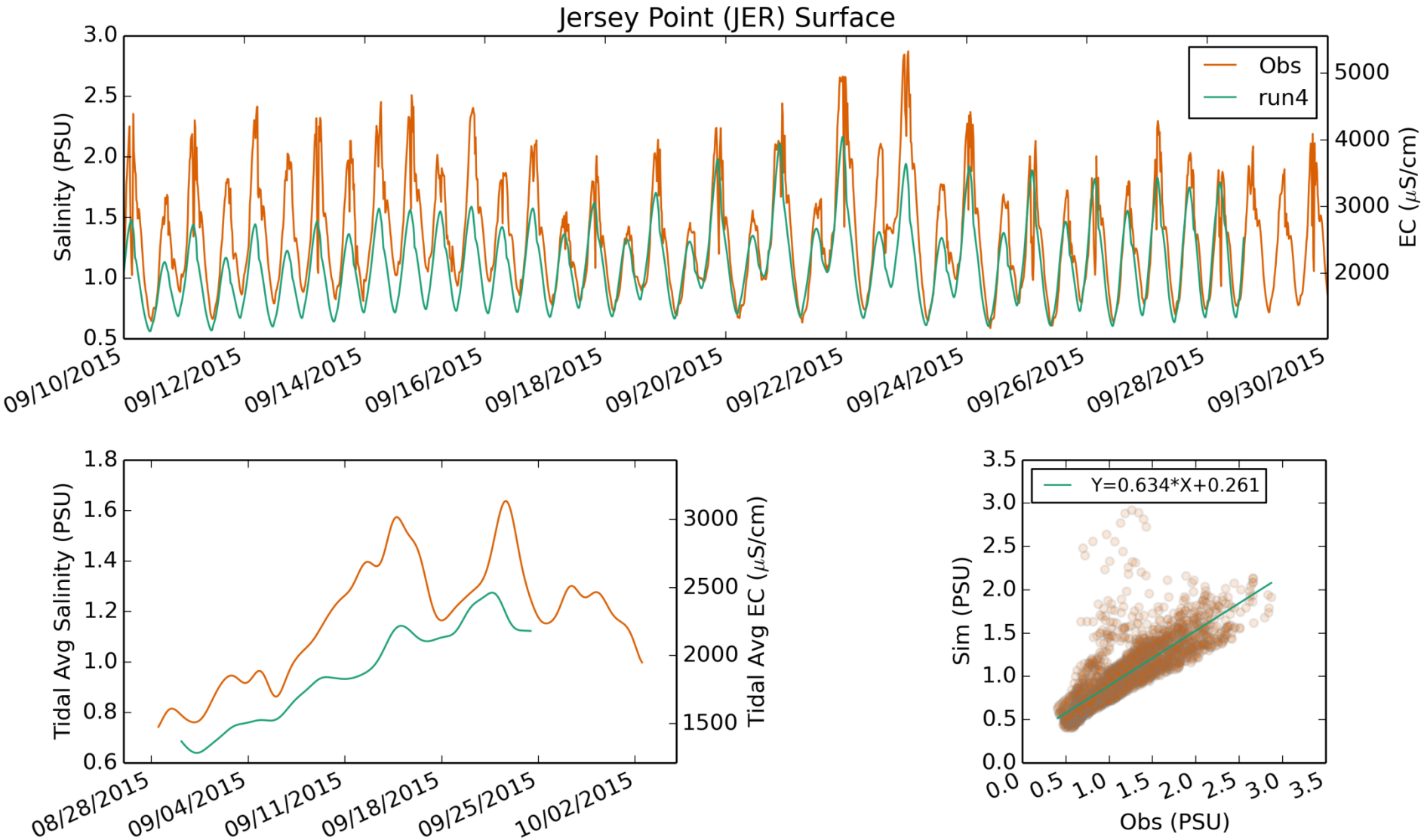
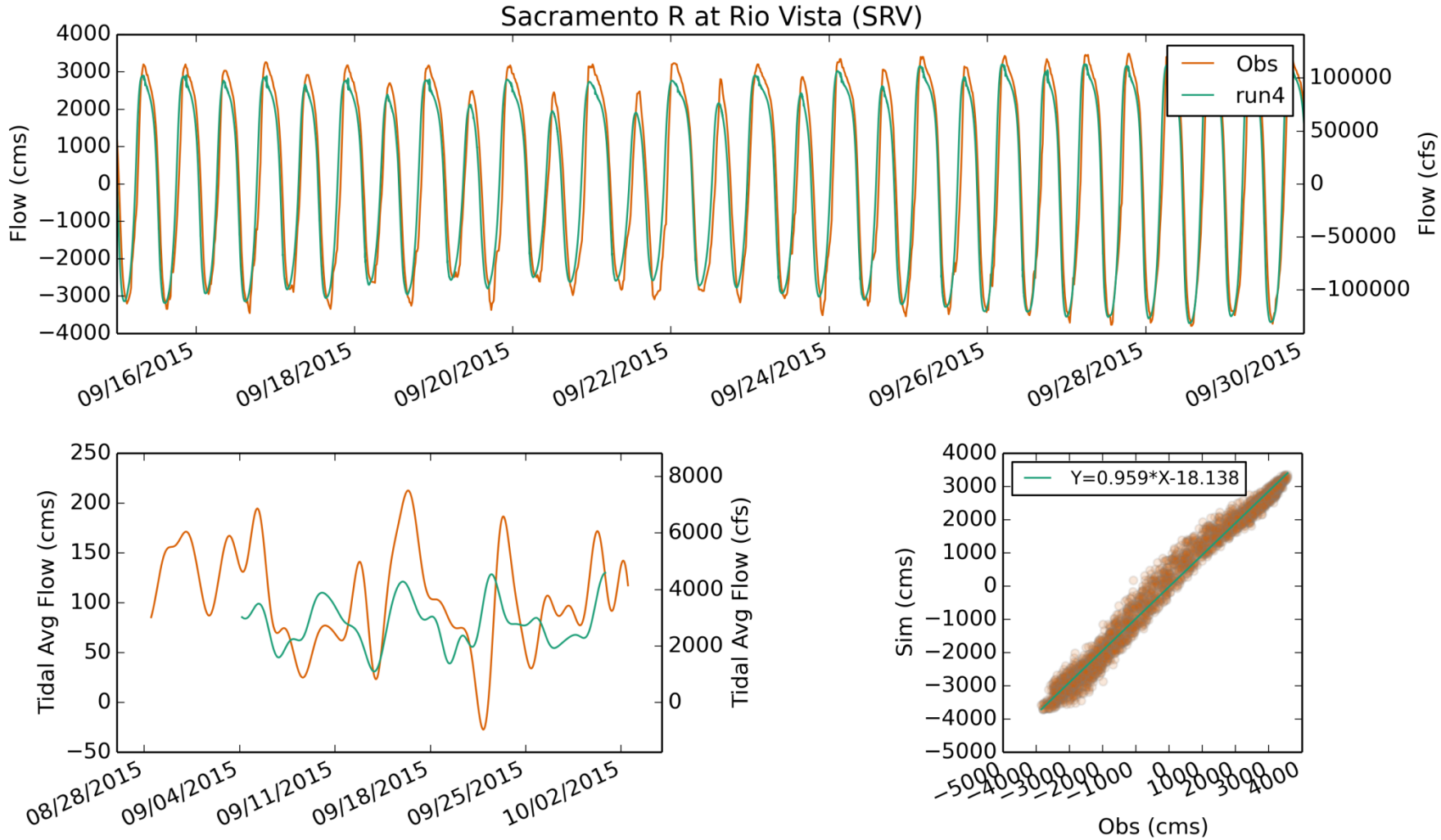
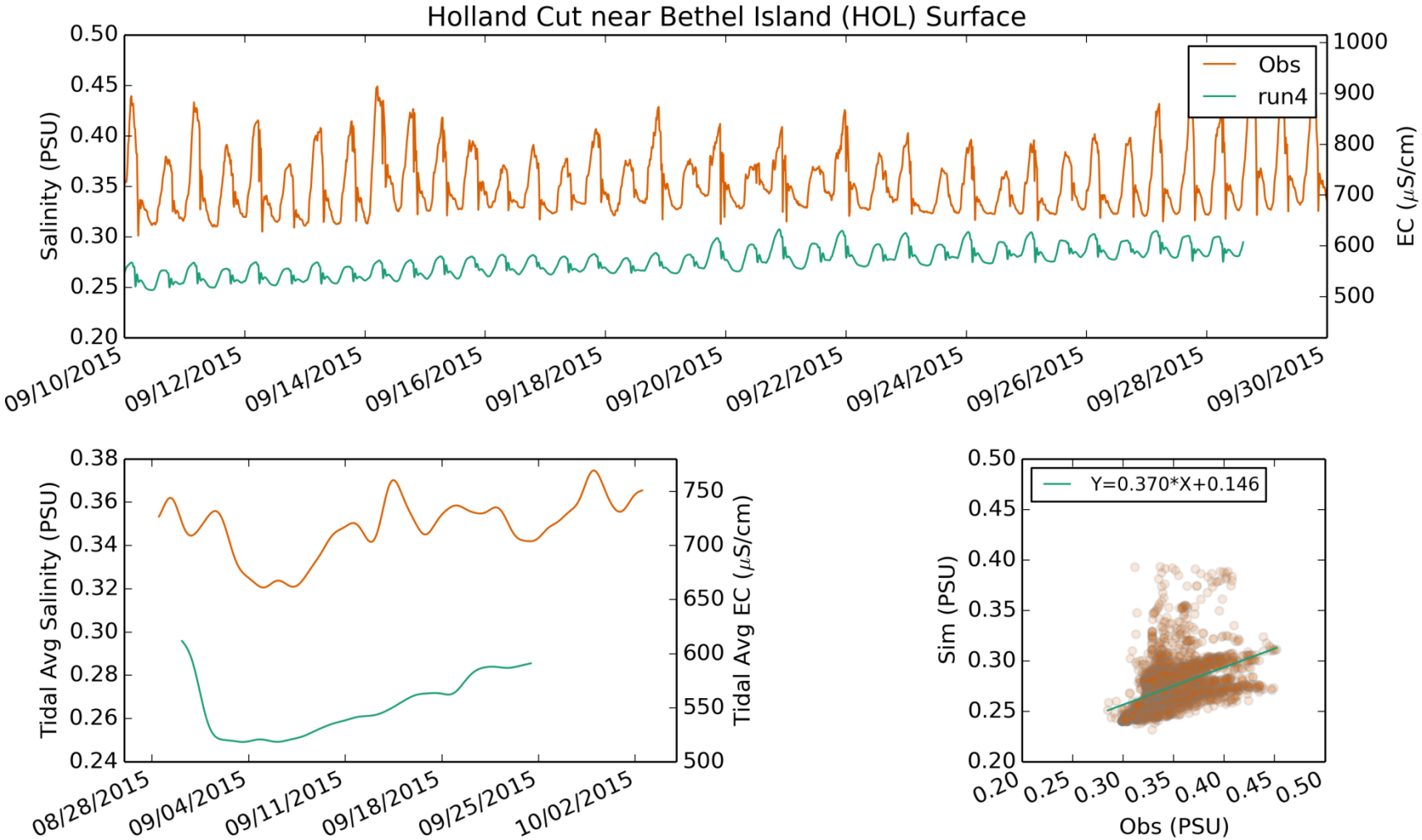
Fishermans Cut (FCT)
Franks Tract (FRK)
Piper/Bethel (BET)
Holland Tract (HOL)
Clifton Ct (CLC)
EC (micromhos/cm)
3000
2500
2000
1500
1000
500
May 2015
Jun 2015
Jul 2015
Aug 2015
Sep 2015
Oct 2015



run4: RMSE=0.320 PSU Lag=-36 min $Bias_{\phi}$=-0.127 NSE_{ϕ}=0.542 R_{ϕ}=0.812

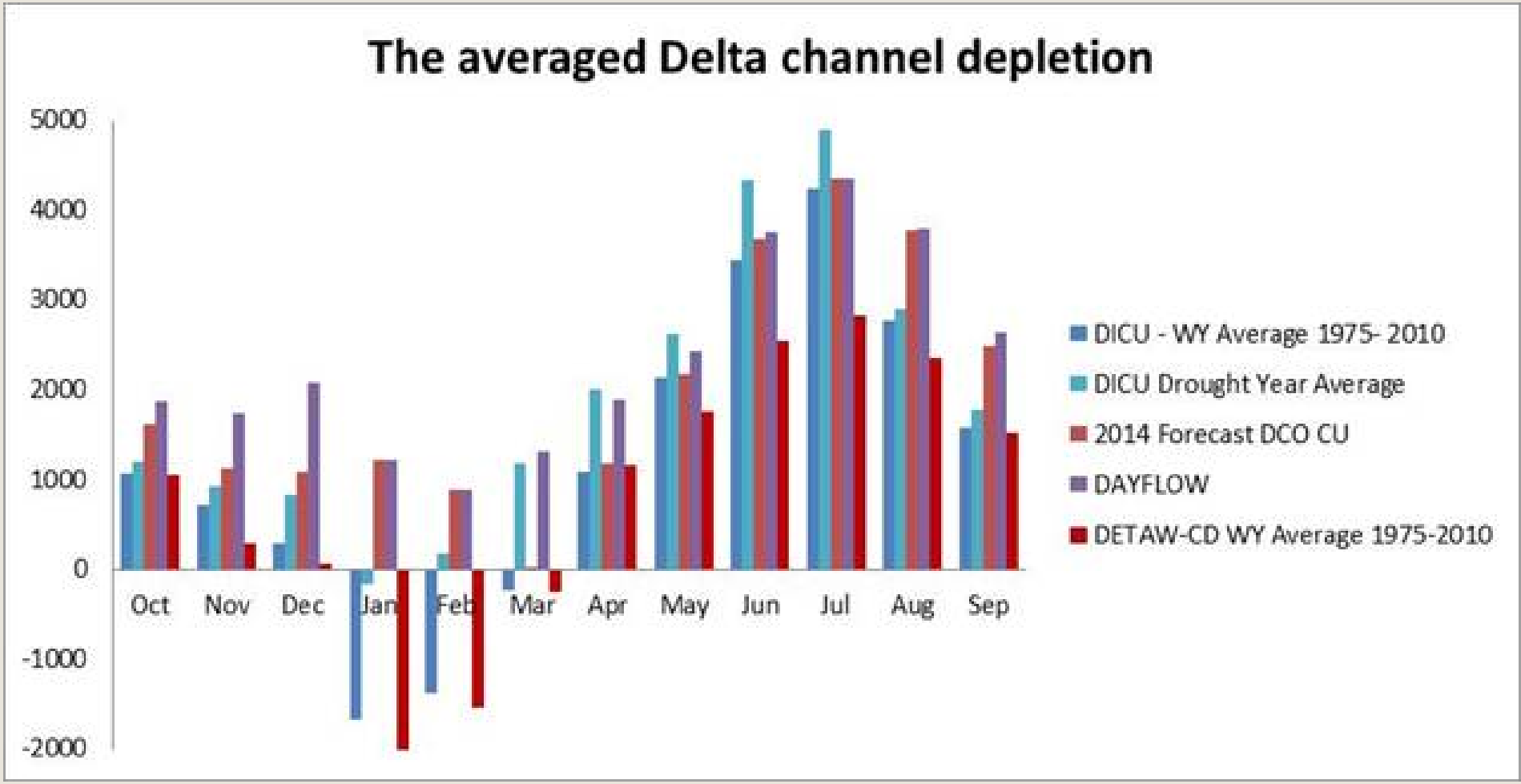


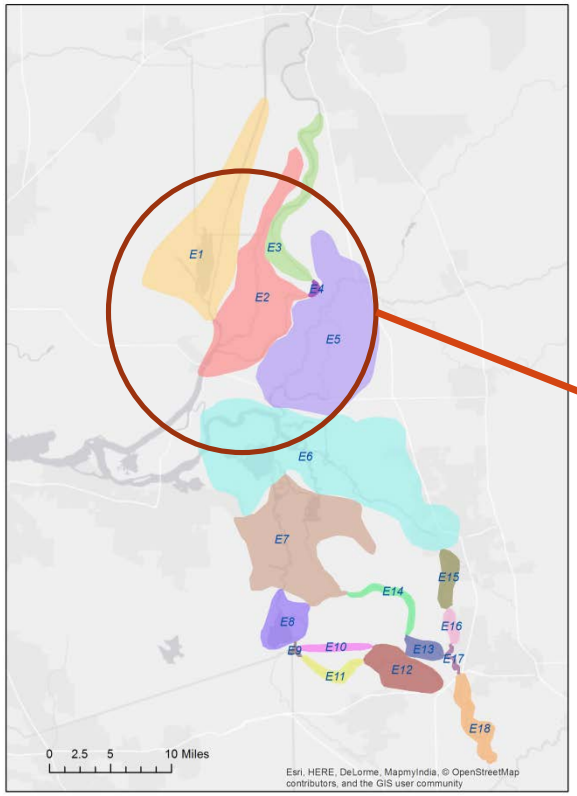
run4: RMSE=771.869 cms Lag=-33 min $Bias_{\phi}$ =-73.284 NSE_{ϕ} =0.985 R_{ϕ} =0.993

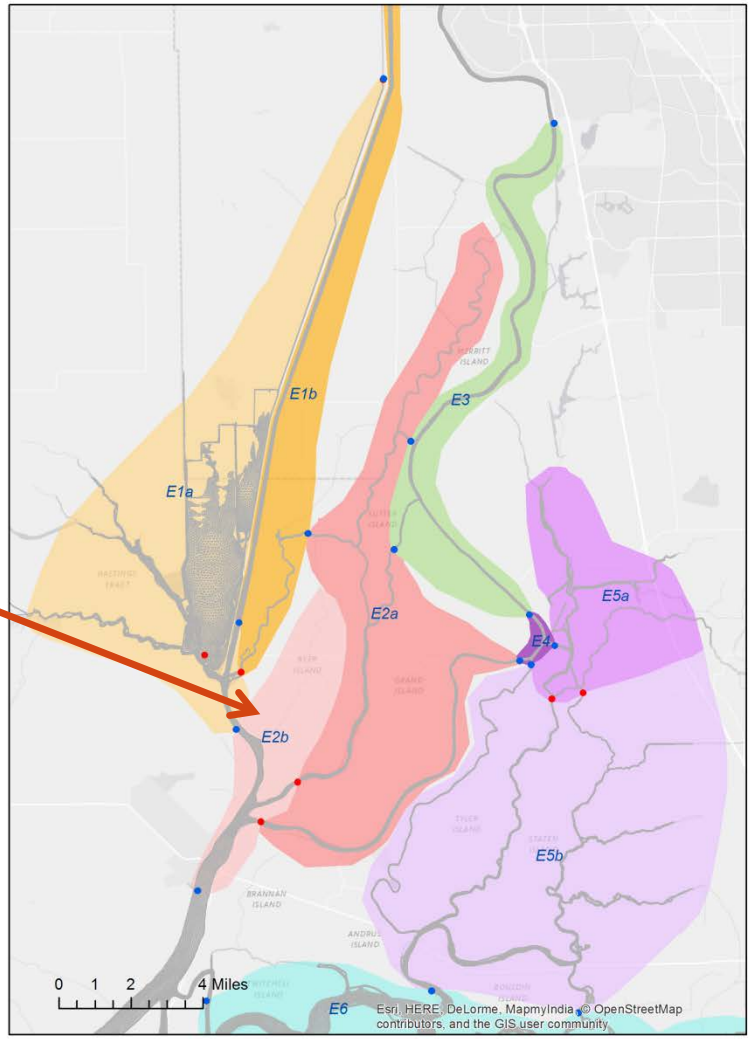


run4: RMSE=0.078 PSU Lag=-69 min $Bias_{\phi}$ =-0.070 NSE_{ϕ} =-6.137 R_{ϕ} =0.456

Consumptive Use Models




E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
E13
E14
E15
E16
E17
E18
0 2.5 5 10 Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


E1b
E1a
E3
E2a
E2b
E4
E5a
E5b
E6
0 1 2 4 Miles
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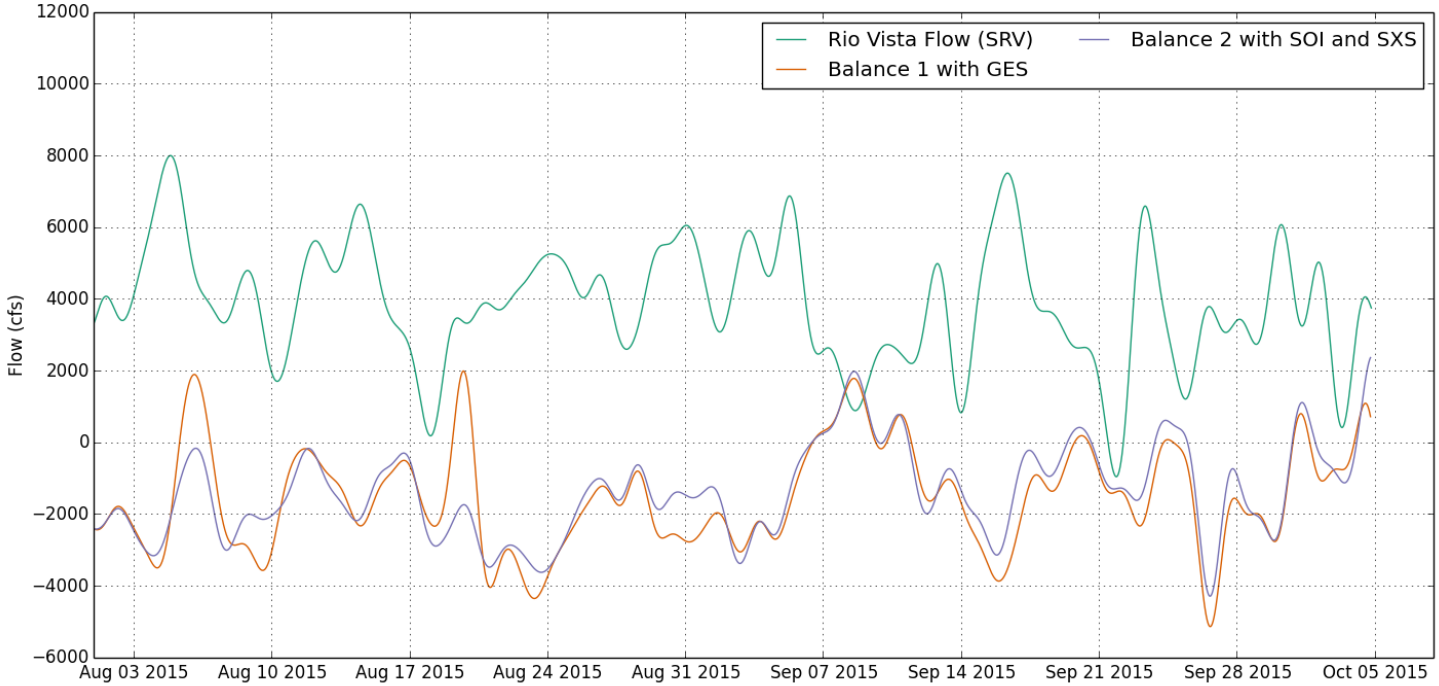
Subtidal Flow Data



Operational Challenges

- Subtidal pressure events
- Spinup and long memory
- Consumptive use
- Leakage (2000cfs at peak)

Barrier Topics

- Screening and selection ✓
- Water cost analyses ✓
- How does the West False River Barrier work? ✓
- Model role in monitoring✓
- Operational modeling and some challenges✓

Overall Summary

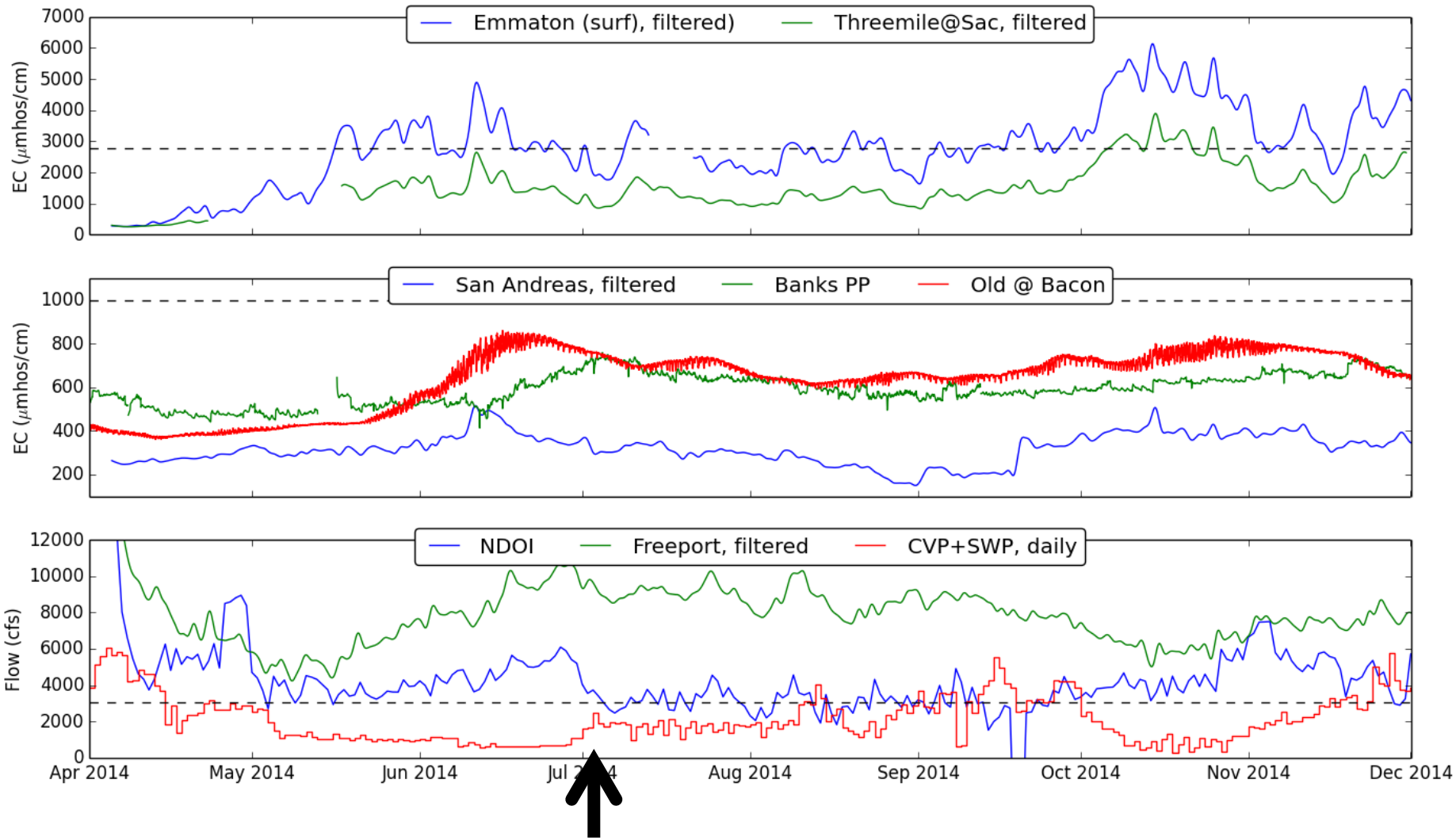
- W. False R. barrier effectively slowed salinity, changed tidal patterns
- Models used in design, outreach and monitoring
- What we learned useful in other contexts like habitat restoration
- Sense of urgency and design of monitoring program both good litmus tests of where we trust models

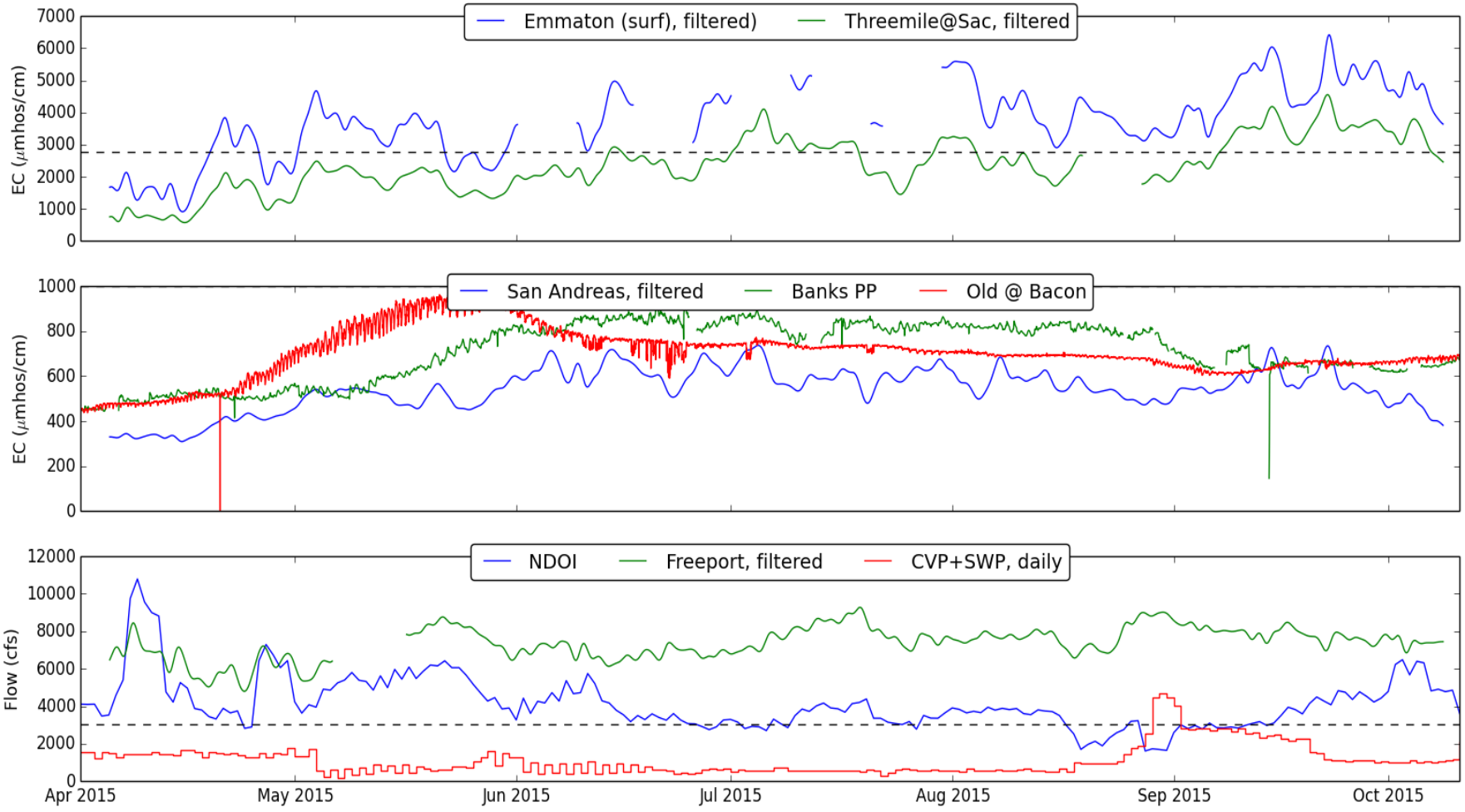
Acknowledgements

- Operations and Maintenance
  - James Edwards, Reza Shacheraghi, Siqing Liu, Dan Yamanaka, Aaron Miller
- Delta Modeling Section
  - Ming-Yen Tu, Tara Smith, Bob Suits, Nicky Sandhu, Kijin Nam, Qiang Shu, Rueen-fang Wang

Questions?

Eli Ateljevich: eli@water.ca.gov
(technical q's about talk)
http://www.water.ca.gov/waterconditions/emergencybarriers.cfm
(DWR Drought Barrier info)


Emmaton (surf), filtered
Threemile@Sac, filtered
EC (μmhos/cm)
7000
6000
5000
4000
3000
2000
1000
0
San Andreas, filtered
Banks PP
Old @ Bacon
EC (μmhos/cm)
1000
800
600
400
200
NDOI
Freeport, filtered
CVP+SWP, daily
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Apr 2014
May 2014
Jun 2014
Jul 2014
Aug 2014
Sep 2014
Oct 2014
Nov 2014
Dec 2014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